ELECTRICAL ENGINEERING

Registered United States Patent Office

JANUARY
1954

The Cover: Dead-end power on Philip Sporn–Kanawha River transmission line, the first 330-kv line in America. See digest on page 61.

1953 Engineering Developments

Reviewed by AIEE Technical Committees . . . 1
A Photographic Record . . . 4
Production of Unipolar Air With Radium Isotopes . . . T. L. Martin, Jr. . . . 28
Motor Insulation Life as Measured by Accelerated Tests and Dielectric Fatigue . . . C. J. Herman . . . 33
Universal Meter for Measuring Voltages at High Impedances, Micromicroamperes, and Insulation Resistance . . . W. R. Clark, R. E. Watson, G. C. Mergner . . . 41
Puncture Tests on Porcelain Distribution Insulators Using Steep-Front Voltage Surges . . . J. H. Park, H. H. Cones . . . 45
Niagara Falls—60 Years of Power . . . C. A. Powel . . . 53
Characteristic Power Requirements in Underground Coal Mines . . . H. P. Musser . . . 57
Microwave as Applied to Railroad Operation in the Gulf Coast Area . . . L. R. Thomas . . . 63
Synchronized Magnetic Tape Recording . . . R. H. Ranger . . . 69

TECHNICAL PAPER DIGESTS

Economy Loading Simplified . . . J. B. Ward . . . 38
Submarine Cables . . . Andrew Bodicky . . . 39
Power Cable Crossings on Bridges and Viaducts . . . D. C. Hawley . . . 40
Prime Mover Speed Governors . . . P. G. Ipsen, J. R. Norton . . . 50
Flux Preset High-Speed Magnetic Amplifiers . . . C. B. House . . . 51
Life of Silver-Surfaced Contacts on Arcing Duty . . . W. R. Wilson . . . 52
A New Control for Heavyweight Rapid-Transit Cars . . . I. W. Lichtenfels . . . 56
American Gas and Electric 330-Kv System Equipment . . . F. A. Lane, J. H. Kinghorn, F. M. Porter . . . 61
Evaluation of Cable Movement Due to Cyclic Loading . . . C. A. Bauer, R. J. Nease . . . 62
Interconnected Systems Energy Accounting . . . M. J. Lacopo . . . 68

MISCELLANEOUS SHORT ITEMS: Germanium Photocell, 37; Wrist Radio Transmitter, 49; Radio Disturbance Warnings, 55; Automatic Method for Helicopter Control, 67

Institute Activities . . . 74
AIEE Fellows Elected, 89; AIEE Personalities, 92; Obituary, 96; Membership, 96

Of Current Interest . . . 97
New Books, 104; Pamphlets, 104

Industrial Notes . . . 26A
New Products, 38A; Trade Literature, 46A

Index to Advertisers . . . 64A

Statements and opinions given in articles appearing in *ELECTRICAL ENGINEERING* are expressions of contributors, for which the Institute assumes no responsibility. Correspondence is invited on controversial matters.

Published monthly by the

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS

Founded 1884

Headquarters
33 West 39th Street
New York 18, N. Y.

Editorial Offices
500 Fifth Avenue
New York 36, N. Y.

Charles S. Rich
Editor

G. C. Baxter Rowe
Associate Editor

F. A. Norris
Business Manager

J. S. Lopes
Advertising Director

VOL. 73 NO. 1

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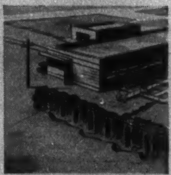
LEAD-COVERED CABLES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HIGHLIGHTS........

1953 Index. The 1953 Index to *Electrical Engineering* is being distributed with this issue as Section 2. It is subdivided into subject, author, AIEE and non-AIEE news, and biographical indexes.

1953 Engineering Developments. At the close of each year, the many achievements and developments in the field of electrical engineering during the past 12 months are considered and evaluated. In this issue a picture survey reflecting some of the year's significant engineering developments is presented, and a number of the AIEE technical committees review various outstanding engineering developments of 1953 that fall within their particular scopes (*pages 1–27*).

Institute Activities. This year's Winter General Meeting in New York City once more will feature the largest technical program in Institute history. As usual, a number of particularly interesting inspection trips are being planned in conjunction with this meeting (*pages 74–82*). Of recent interest was the sixth annual Conference on Electronic Instrumentation and Nucleonics in Medicine which was held jointly with the Institute of Radio Engineers and the Instrument Society of America in New York City in November (*pages 83–4*). Biographical sketches of members elected to the grade of Fellow in the AIEE as of November 5, 1953, are included in this issue (*pages 89–92*).

Of Current Interest. With the first public demonstration of recording of television on magnetic tape in both color and black-and-white, the laboratories of the Radio Corporation of America presented, on December 1, a preview of techniques that will simplify the entire art of making pictures in motion (*pages 97–8*).

News Index

Institute Activities....................74

Winter General Meeting....................74
Future AIEE Meetings....................74
Conference on Electronic Instrumentation.....83
AIEE-ASME Membership Privilege............85
Committee Activities....................88
AIEE Fellows Elected....................89
AIEE Personalities....................92
Obituary....................96
Membership....................96

Of Current Interest....................97

Magnetic-Tape Recording of TV Pictures......97
Future Meetings of Other Societies............97
Most Powerful Radio Transmitter............98
New Books....................104
Pamphlets....................104

Unipolar Air Produced With Radium Isotopes. This article presents an examination of developments made recently in atmospheric ionization apparatus designed for use at high air speeds. Both operating characteristics and design considerations are treated briefly (*pages 28–33*).

Accelerated Tests and Dielectric Fatigue as Measurements of Motor Insulation Life. Accelerated life tests on motors plus dielectric fatigue measurements on stators have located conclusively the weakest portions of the insulation systems. Nondestructive overvoltage measurements have proved most useful for locating initial weak spots and as they develop during life tests before failures occur as well as providing clues regarding life expectancy (*pages 33–7*).

Microwave System Applied to Gulf Coast Railroad Operation. Besides furnishing communication facilities in addition to the existing wire lines, this installation was made to provide technical information concerning microwave relay system reliability under adverse conditions. It is discussed together with the fading problems which were solved (*pages 63–7*).

Universal Meter for Measuring Voltages at High Impedances. This instrument is a relatively simple and versatile unit which can measure voltages up to 500 volts in high-impedance circuits, currents as low as 10^{-18} ampere, and insulation resistance up to 10^{8} megohms with limits of error of 1.5, 3.5, and 5 per cent respectively. It employs a chopper-type stabilized feedback amplifier which is entirely a-c powered. It causes negligible errors due to insertion of the instrument in circuits and permits measurement of insulation resistance in accordance with approved American Society for Testing Materials methods (*pages 41–5*).

Steep-Front Voltage Surges Test Ability of Porcelain Insulators to Withstand Direct Lightning Strokes. Voltage surges with rates of rise up to 10,000 kv per microsecond were used to compare distribution insulators of various designs and makes. Puncture failures similar to those obtained in the field due to lightning strokes were produced in the laboratory (*pages 45–9*).

Niagara Falls Power. It was just 60 years ago that an order first was placed with Westinghouse for electric generators to be operated from power derived from Niagara Falls. A tribute to some of the men who undertook the pioneer development is in order on this diamond jubilee, and is of special interest in view of recent proposals to develop additional Niagara power (*pages 53–5*).

Bimonthly Publications

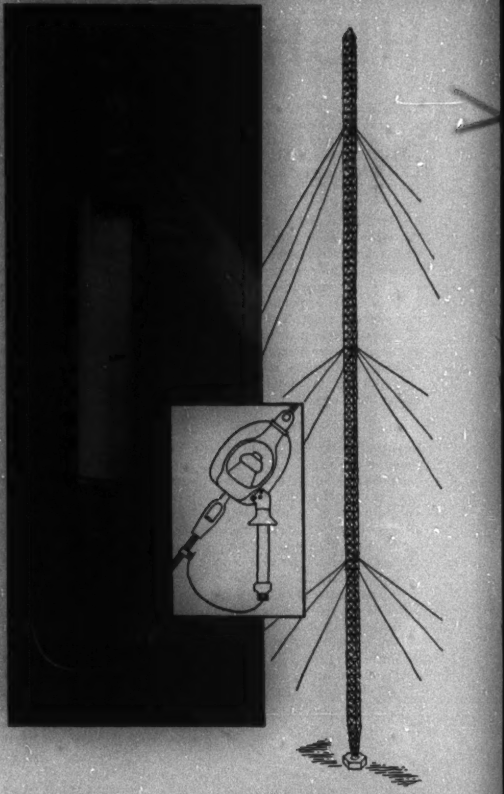
The bimonthly publications, *Communication and Electronics*, *Applications and Industry*, and *Power Apparatus and Systems*, contain the formally reviewed and approved numbered papers presented at General and District meetings and conferences. The publications are on an annual subscription basis. In consideration of payment of dues, members (exclusive of Student members) may receive one of the three publications; additional publications are offered to members at an annual subscription price of $2.50 each. The publications also are available to Student members at the annual subscription rate of $2.50 each. Nonmembers may subscribe on an advance annual subscription basis of $5.00 each (plus 50 cents for foreign postage payable in advance in New York exchange). Single copies, when available, are $1.00 each. Discounts are allowed to libraries, publishers, and subscription agencies.

Characteristic Power Requirements in Underground Coal Mines. The connected horsepower sometimes is an indication as to what the energy and demand requirements will be for a specific operation such as for haulage locomotives. However, often the horsepower rating is not reflected in the demand created or energy used as in the case of mining machines. Each operation is affected by different factors which largely may determine the power consumption such as the manner in which distance and grade affect haulage power requirements (*pages 57–60*).

Synchronized Magnetic Tape Recording. Sound has been recorded magnetically on an iron-oxide track coated on moving-picture film and its perforations have accomplished the lock-in. Synchronism has been accomplished by recording both the sound and a control track on $^{1}/_{4}$-inch tape, as explained in this article (*pages 69–73*).

Membership in the American Institute of Electrical Engineers, including a subscription to this publication, is open to most electrical engineers. Complete information as to the membership grades, qualifications, and fees may be obtained from Mr. H. H. Henline, Secretary, 33 West 39th Street, New York 18, N. Y.

ELECTRICAL ENGINEERING. Published monthly by the American Institute of Electrical Engineers; publication office 20th & Northampton Streets, Easton, Pa. Editorial and advertising offices 300 Fifth Avenue, New York 18, N. Y. Subscription $12 per year plus extra postage charge to all countries to which the second-class postage rate does not apply; single copy $1.50. Entered as second-class matter at the Post Office, Easton, Pa., under the Act of Congress of March 3, 1879. Accepted for mailing at special postage rates provided for in Section 538, P. L. & R. Act of February 28, 1925.
January 1954, Vol. 73, No.1. Number of copies of this issue 58,600



THIS IS A PORCELAIN-HOUSED RESISTOR

From the earliest days of radio broadcast, a large proportion of all insulators used in antenna structures have been designed and made by Lapp. And the mechanical and electrical requirements of insulators for this duty have been among the most challenging and provocative in our considerable "specialty" experience.

Most of the higher-powered broadcast stations transmit from vertical radiators—steel towers—the tallest of which are guyed structures, resting on a single porcelain base insulator, and held by one or more sets of guy wires. The guying cables must be insulated from the tower, and also be broken into short sections. Lapp radio guy insulators—cast steel frames carrying porcelain compression cones and center-bolt to complete mechanical linkage—are used for this purpose.

Under certain operating conditions, flashover of these insulators occurred far too often. This was not due to excess voltage on the tower, to lightning, nor to leakage current. After considerable investigation, the mystery was solved—it appeared that an accumulation of static charge, built up on the insulated cable sections by wind or snow, finally reached arcover voltage. Radio frequency current followed the ionized path.

As so many times in the past, in the radio and electrical fields, the problem was assigned to Lapp. The device shown in the photograph proved to be a completely satisfactory solution. It is a porcelain tube, with caps which fasten to the frame of the guy insulator, and to the cable below. Inside the porcelain tube is a resistor of such value that it results in no appreciable loss of radio-frequency energy, but does permit a steady leak to ground of the static charges.

When you listen to your favorite radio station, you are probably benefiting by the better quality of reception and freedom of interruption made possible by this and other Lapp-engineered-and-built radio specialties. Just as customers of electrical utilities the world over are benefiting from the dependability of service made possible by Lapp-engineered-and-built porcelain for system equipment, and transmission and station insulation. Lapp Insulator Co., Inc., Le Roy, N.Y.

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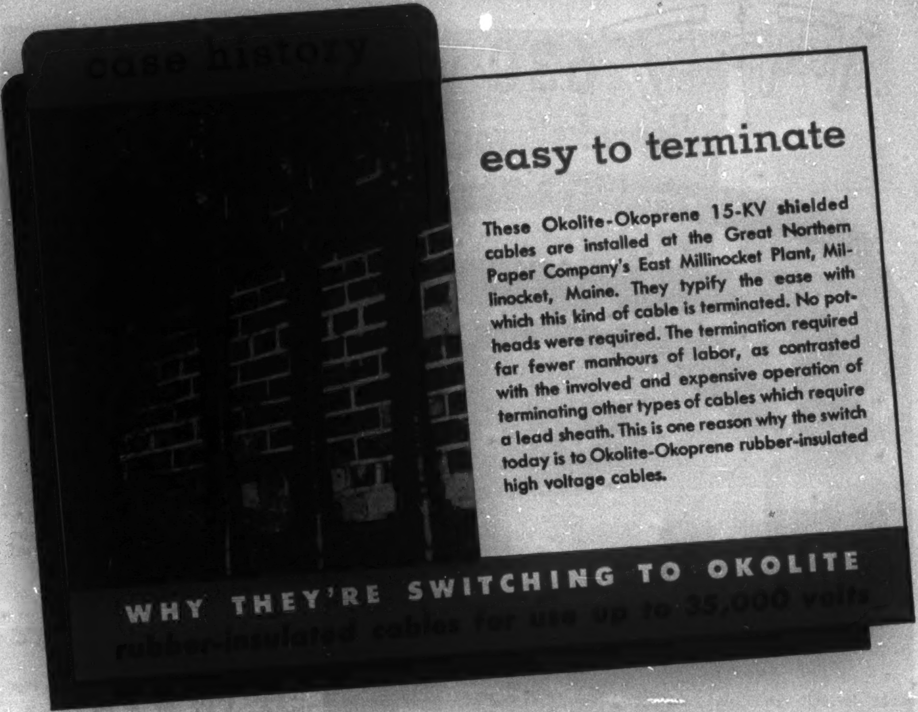
case history
WHY THEY'RE SWITCHING TO OKOLITE
rubber-insulated cables for use up to 35,000 volts

easy to terminate

These Okolite-Okoprene 15-KV shielded cables are installed at the Great Northern Paper Company's East Millinocket Plant, Millinocket, Maine. They typify the ease with which this kind of cable is terminated. No potheads were required. The termination required far fewer manhours of labor, as contrasted with the involved and expensive operation of terminating other types of cables which require a lead sheath. This is one reason why the switch today is to Okolite-Okoprene rubber-insulated high voltage cables.

There is a distinct trend among industrials and public utilities toward Okolite rubber-insulated cables for high voltage use.

ADVANTAGES

1. **Lighter and easier handling.**
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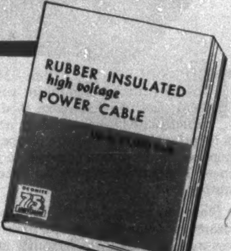
5. **No oil migration at high temperatures or elevations.**
6. **Flexibility simplifies installation.**

APPLICATIONS

1. **Transmission and distribution circuits.**
2. **Generator and transformer leads.**
3. **Vertical risers and shaft cables.**
4. **Submarine power cables.**
5. **Portable substation cables and test leads.**
6. **X-ray cables.**



Send for this 128-page manual on rubber-insulated high voltage cable. It provides current carrying capacity tables, dimensional data, engineering information and installation procedures, complete instructions and detailed drawings for splices and terminations. Write for Bulletin EG-1075 on your letterhead to The Okonite Company, Passaic, New Jersey.

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Since the scales of any VOM comprise the means by which it makes its multiple services most valuable, the legibility and easy-read-ability are of prime importance. Triplett engineers have created in Triplett 630 the longest scales available in this size tester. (The upper arc by actual measurement is four and three-eighth inches.)

This long-scale factor accounts for the ease with which precise readings are easily made. Further legibility is gained by use of black and red scale markings. D.C. and D.B. are black and white. A.C. and Ohm markings are red on white. Ohms from one hundred million to one-tenth ohm mark the range of this amazing scale. On low ohms, center scale reading is 4.5 ohms.

The Single Switch

Futher indication of the practical skill and engineering "know-how" behind Triplett 630 is the Single Switch. Its simplicity of operation assures no burn-outs thru momentary memory lapses. There is instant switching to desired circuit thru a single 2½" knob flush with the face panel. The molded switch itself embodies the most advanced engineering practices. Fully enclosed, the silvered contacts are kept permanently clean. Its rugged construction means stronger performance and longer life.

These two factors are but samples of the many ways in which on-the-job needs have been anticipated and provided for in a beautiful streamlined tester. It provides A.D-D.C. Volts, D.C. Micro-amperes, Milliamperes, Amperes, Ohms, Megohms, Decibel and Out Put readings in a no-short design embodying interior construction with all direct connections; no harness cabling. Its fool-proof unit switch construction houses precision resistors in insulated recesses in direct connection with switch contacts.

Study the following Ranges and descriptions and compare them point by point with *any* similar instrument for conclusive proof that Triplett 630 "speaks" for itself in *any* company.

Ranges

D.C. Volts: 0-3-12-60-300-1200—at 20,000 Ohms/Volt (For Greater Accuracy on TV and other High Resistance Circuits.)
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(For Greater Accuracy in Audio and other High Impedance A.C. Circuits.)
Decibels: —30, +4, +16, +30, +44, +56, +70.
(For Direct Reading of Output Levels.)
D.C. Microamperes: 0-60—at 250 Millivolts.
D.C. Milliamperes: 0-1.2-12-120—at 250 Millivolts.
D.C. Amperes: 0-12—at 250 Millivolts.
***Ohms:** 0-1,000-10,000—(4,4-44 at center scale).
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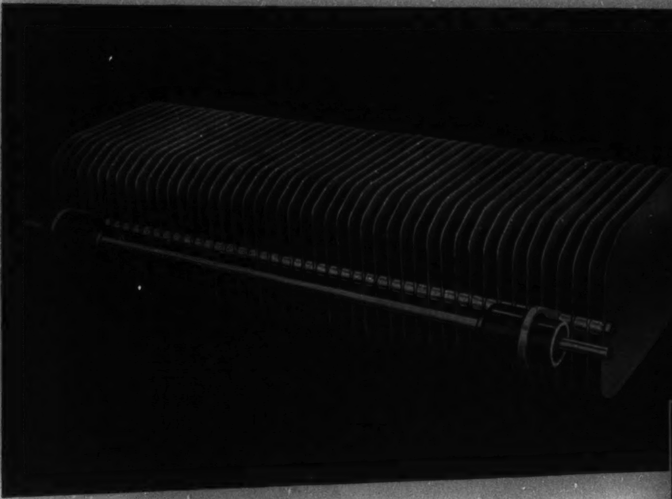

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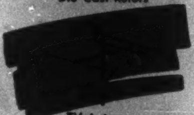
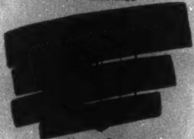
Aluminum readily lends itself to a slight etching process which provides a capillary surface for the retention of a heavy film of oil for trapping impurities out of the air. This process also tends to round the edges of the plates which minimize electrical loss.

Important, too, is the low cost of aluminum. This makes it practical to keep a spare set of assemblies on hand, cutting down on the time the filter has to be out of service. Thus it is easy to see how the unique advantages of aluminum by Reynolds can be used to cut costs, weight and maintenance expense in electrical equipment.

Die Cast Rotors

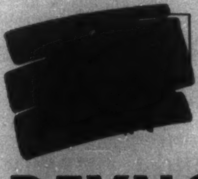


TV Antennas



Meter Boxes

Conduit Fittings



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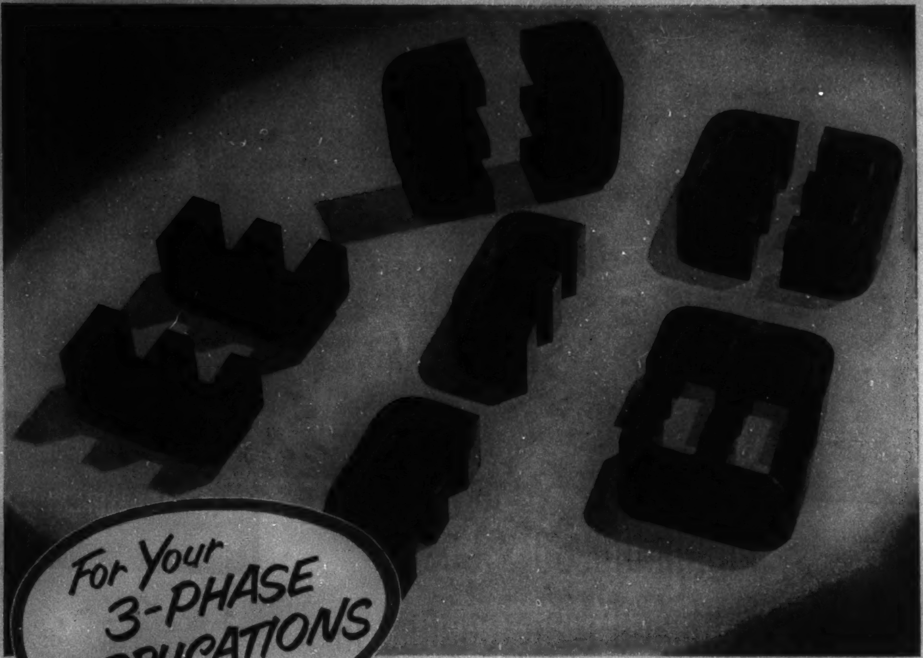

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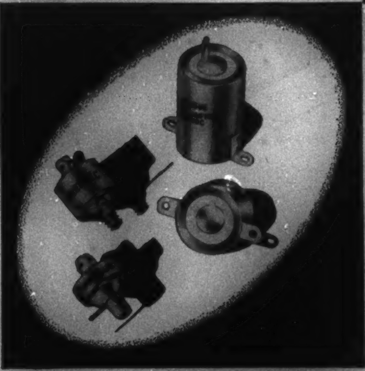

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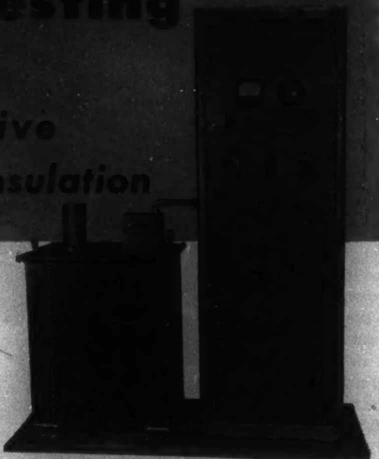
BIDDLE Corona Testing Equipment

...for non-destructive evaluation of electrical insulation

Model 1, .75 KVA, 20 KV continuously or 1.5 KVA for intermittent duty. Also available with a larger control unit with a rating of 2 KVA continuous and 5 KVA intermittent duty.



Model 2, rated up to 10 KVA, 35 KV continuously or 20 KVA intermittent duty.

Safety, Simplicity, and Reliability have been engineered into Biddle Corona Test Sets to such a degree that operation by engineering personnel is not required. The facility and efficiency of these sets in the hands of average individuals makes them highly practical. Our wide experience in the field of insulation testing and the development of practical, easy-to-use equipment for this purpose is reflected in these Corona Test Sets. Experience indicates that the life of cable, transformers, motors, generators, and other such equipment may be shortened by operation at voltages substantially higher than the corona or ionization starting voltage. It is a known fact that the corona starting voltage is not always constant but may decrease with aging.

With the Biddle Corona Test Set non-destructive evaluation of insulation by corona testing is now practical as a production control of quality of insulating structures.

Biddle Corona Test Sets consist of a control unit, a detector unit, and a high voltage corona-free testing transformer which incorporates means for picking up corona signals from the equipment under test. The frame of such equipment may be grounded. This is a "must" for practical testing.

Figure 1—Showing the detector panel indicating a voltage just below the corona starting voltage on a typical sample.

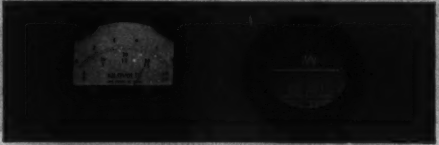


Figure 2—Showing the detector panel after increasing the voltage above the corona threshold.

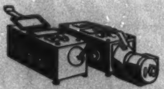
In operation, the equipment to be tested is connected to the high voltage terminal of the testing transformer, and 60 cycle test voltage is increased until corona indication appears on the cathode ray tube in the detector unit. The rms equivalent of peak voltage is then read from the adjacent peak voltmeter.

Write for **BULLETIN 66-EE**

B-937

JAMES G. BIDDLE CO.

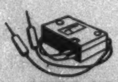
Electrical & Scientific Instruments • 1316 Arch Street • Philadelphia 7, Pennsylvania



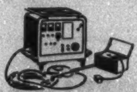
MEGGER INSULATION RESISTANCE TESTERS

DUCTER LOW RESISTANCE OHMMETER

MEG-TYPE MEGGER INSULATION TESTER

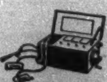


MIDGET MEGGER CIRCUIT TESTING OHMMETER



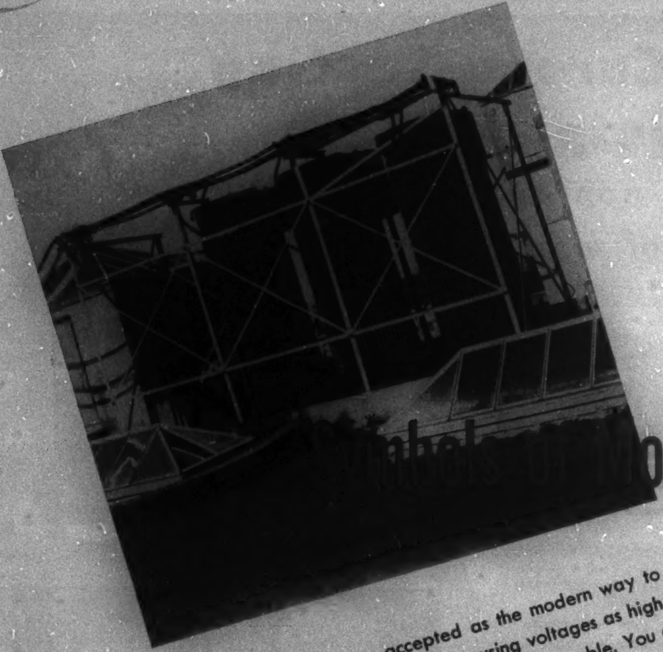
BIDDLE IMPULSE CABLE FAULT LOCATOR

MEGGER LOW RESISTANCE OHMMETER



"TTR" TRANSFORMER TURN RATIO TEST SET

Vol. 73
1953



Symbols of Modernization

Unit load centers are rapidly becoming accepted as the modern way to distribute power inside an industrial plant. This frequently involves using voltages as high as 17,000 volts. That's too high a voltage to be trusted to just any ordinary cable. You can't afford mediocrity in these important cables. Simplex-ANHYDREX XX should be your choice.

Simplex-ANHYDREX XX is a product of Simplex research and development. It is an insulation that is absolutely "tops" in the high voltage field. It is designed to operate at a maximum of 176°F. (80°C.) copper temperature.

Simplex-ANHYDREX XX has all the properties you want in a high voltage rubber insulation. It withstands heat, ozone and aging, and it is guaranteed not to absorb more than 15 milligrams of water per square inch of exposed surface when tested in accordance with U. S. Coast Guard standards.

So far as we know it is the only insulation of its kind. Use it wherever you have a high voltage problem, whether the cables are to be installed directly in the earth, underground in ducts, underwater, or overhead supported from messenger wire.

Simplex-ANHYDREX XX Cables are available in single and multiconductor styles for voltages from 2,000 to 17,000 V.W.P.

Simplex

SIMPLEX WIRE & CABLE COMPANY, 79 Sidney St., Cambridge 39, Mass.

1953 ENGINEERING DEVELOPMENTS

Reviewed by AIEE Technical Committees

MANY NOTABLE engineering developments during the year 1953 have been reported by 24 technical committees in all of the five broad divisions of Institute activities.

In the field of communication, the microwave radio relay routes have been extended with over 27,000 miles in television service, thus ever-widening the television audiences, and color television signals have been transmitted successfully over these facilities. Yeoman service has been performed by the National Television System Committee in obtaining industry-wide agreement on a set of standards for a compatible color and black-and-white television system which is now before the Federal Communications Commission for approval. Developments were climaxed toward the end of the year by the RCA demonstration of magnetic tape recording of television pictures in color and black-and-white with sound.

In the field of computing devices, the speed, accuracy, and capacity of memory storage abilities have been increased greatly. The uses of computers have been extended to many types of design, operation, and production problems, both in the field and laboratory, as evidenced in the reports of several of the committees. For example, their use in combination with feedback controls and a flight simulator greatly has decreased the time needed to design autopilots. In the field of power transmission, both the analogue and digital types of computers are being applied to a wide range of problems.

In the field of power, the outstanding development of the year was the decision of one company to have designed and built a 120,000-kw unit to operate at the supercritical throttle pressure of 4,500 pounds per square inch gauge and 1,150 degrees Fahrenheit. A drumless steam generator of the once-through type will be employed. Research on transmission at the higher voltages continues and the building of large transformers, oil circuit breakers, and air-break switches for the 330-kv system or 330-kv service have been announced.

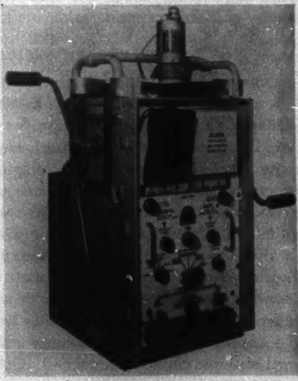
Communication

RADIO SYSTEMS

ONE OF THE newer requirements of the Safety of Life at Sea Convention in the marine communication field is a portable radiotelegraph transmitter and receiver for use in life boats. Watertight, self-contained crystal-controlled radio stations, including power supply and antenna system with an output of 2 watts on 500 kc and 5 watts on 8,364 kc, have been developed for this purpose. A hand-driven generator furnishes power so that no batteries are required. The equipment automatically transmits the international alarm and SOS signals on 500 kc, followed by SOS signals and a 30-second dash for direction finders on 8,364 kc.

More than 3,000 miles of new radio relay routes were placed in service by the Bell System during 1953 bringing the total route miles of such facilities at the end of the year to about 10,300. Over 62,000 miles of 1-way broad-band channels were in operation on these microwave routes, of which over 27,000 miles were used for television service. The remaining broad-band channels were being used for telephone service and for service protection. Some 4,000,000 miles of telephone circuits were in operation over the microwave facilities by the end of 1953. National Television System Committee color television signals also were transmitted successfully over the microwave radio facilities from New York, N. Y., to Chicago, Ill., and Los Angeles, Calif., thus demonstrating the practicability of nation-wide color-television network service.

In the international radiotelegraph field an additional eight United States overseas channels, for a total of 32,



Portable radiotelegraph transmitter and receiver for use in lifeboats. The output is 2 watts on 500 kc and 5 watts on 8,364 kc

now use equipment which automatically interrupts the channel upon receipt of a mutilation and retransmits the character until properly received.

SWITCHING SYSTEMS

A NEW AND fully automatic teletypewriter switching center for military use was placed in service by the United States Army Signal Corps. Developed by Automatic Electric Company in co-operation with the Signal Corps, the new switching center incorporates unusual military requirements not encountered in domestic telephone and telegraph switching systems. A great variety of types and classifications of military messages are received and automatically routed toward their several destinations. Provision is made for the processing of multiple address messages. Also, messages carrying different degrees of priority are recognized automatically and acted upon in the desired manner without human intervention.

Attempts to utilize transistors in switching circuits have found commercial application by the Bell System in a card translator. The card translator assists in the establishment of telephone connections in nation-wide toll dialing. Inherent small size and the unique properties of transistors and phototransistors made the design possible. It is among the first commercial applications of transistors and phototransistors in communication switching systems.

The independent telephone companies have evidenced their interest in automatic methods of toll message recording and accounting for their particular needs. Automatic Electric Company has arranged its subscriber toll dialing system to operate with the nation-wide toll dialing plan of the Bell System. North Electric Company has a new toll dialing tape reader.

The Bell System is expanding the installation of equipments required for nation-wide toll dialing. Reports of experience with the new switching systems are anticipated.

Keen interest continues in the application of logic and mathematical analysis to the design of switching circuits. The Bell Telephone Laboratories have extended Boolean Algebra to the design of electronic switching circuits and have announced a map method for the synthesis of combinational logic circuits. It is significant that at least one of our engineering schools now recognizes switching systems worthy of abstract consideration.

TELEGRAPH SYSTEMS

A NEW TYPE of telegraph service board was placed in service by the Bell System in New York, N. Y., and Chicago, Ill. It provides improved facilities for interconnecting subscribers' loops with long-distance lines, for doing necessary testing and patching in case of trouble, and for conveniently rearranging connections as required to meet customer service needs. The connecting circuits are entirely electronic and of a type which connect legs in parallel and permit a single regenerative repeater to serve a complex multiway interconnection. Also, a newly developed concentrator for serving teleprinter exchange lines in groups of 200 over a few trunks was placed in service. It permits further growth in large offices after normal inward multiple capacity is reached. Called stations are connected automatically at the concentrator in response to teletypewriter codes sent by switchboard operators.

Considerable interest has developed in the possible operation of telegraph-type circuits at comparatively high speeds for rapid transmission and recording of material such as stock market closing reports, punched card information direct from card to card, and computer data. Studies and exploratory tests were carried on.

The use of telegraph circuits with telemetering and selective signaling devices of various types expanded considerably during the year.

Applications of facsimile reached into diversified fields. For transmitting news photos on television broadcasts, electrolytic-type facsimile recordings were televised. An interoffice facsimile system using electrolytic recording was made available. Over 11,000 dry-recorder-type machines now serve to pick up and receive telegrams. Facsimile machines for recording mimeograph stencils were made available. An office duplicator which will produce ten copies per minute on ordinary paper or offset printing plates was announced. This machine employs a cathode-ray flying spot scanner and Xerographic process recording. Continuous recorders for 18-inch-wide weather maps have been installed, a dry type in the United States and an electrolytic type in Canada.

TELEVISION AND AURAL BROADCASTING

IN AURAL broadcasting several installations were made of remotely controlled transmitters, up to and including 5-kw power, with important operating savings. Another development was an increase of power in international broadcasting, with at least one installation rated at 1-megawatt carrier output. In the receiver field the use of subminiature tubes and other small components permitted the production of a set with built-in loudspeaker and over-all dimensions of only 6 by $3^1/_2$ by $1^1/_4$ inches. Increased interest in high-fidelity receivers was another development; this was shown in the amateur and custom-built field and also in regularly manufactured receiver models. Several United States stations now offer regular stereophonic service for live musical programs by using two microphones; one supplying the amplitude-modulation transmitter, the other supplying the frequency-modulation transmitter.

In television the number of stations increased greatly to a total of over 300, augmented by increases of effective radiated power, so that the available television audience was substantially enlarged. New tetrodes and klystrons were introduced for delivering high power in the very-high- and ultrahigh-frequency ranges. Receivers were improved with regard to noise figure, definition, synchronization, and larger picture size. A major change was the incorporation of circuits for receiving the ultrahigh-frequency channels.

Intense developmental work on color television culminated during the summer in the proposal by the industry-wide National Television System Committee of a set of standards to the Federal Communications Commission. An impressive demonstration including 13 receivers, each made by a different company, was given in New York in

October 1953, and prospects appear good for the inauguration of regular color service in 1954.

General Applications

DOMESTIC AND COMMERCIAL APPLICATIONS

Heat pumps and electric space heating units are being made by an increasing number of manufacturers who have units in regular production. Practical progress is toward higher over-all performance, lower first cost, and more trouble-free operation. However, fundamental problems still remain under research by many groups, for example: temperature, moisture migration, and heat transfer in the earth used as a heat source and sink; frosting of the outdoor coil with air as the heat source; chemical storage of heat to reduce the maximum peak load and improve the annual load factor. Solar energy also is being explored for primary or auxiliary heat source. Domestic air conditioning is a rapidly growing field with more than 50 manufacturers applying conventional techniques of water- or air-cooled units together with warm-air furnaces to a tremendous mass market by ingenious design to simplify installation and operation.

In the domestic appliances field there has been a variety of developments for the immediate convenience of the user and home owner, such as electronic range surface unit control with power pulsing and temperature control; heat lamps to give rapid heat-up for combination radiant and conductive surface units; an automatic ice maker to keep the ice basket full to a predetermined load; a refrigerator with the fresh-food compartment on top and the frozen-food compartment on the bottom.

In regard to farm electrification there has been a continued and rapid application of electricity to farm chores, as illustrated by the following examples. Poultry: automatic lighting, ventilation, automatic feeders and litter removers. Dairy: 3- to 10-horsepower motors for crop drying, pipe-line milking (cow to cold wall bulk storage tank) with immediate cooling of milk to 36 degrees Fahrenheit. Potato storage: electric fan ventilation to control temperature and humidity closely to minimize rotting, sprouting, and shrinkage. Beef cattle: automatic feeding (necessary to balance the high cost of labor) including motorized conveyors moving grains and cobcorn to grinders, thence to feed mixers for addition of supplements, then blown to storage bins or conveyed to feed bunks.

LAND TRANSPORTATION

Gas-Turbine Electric Locomotives. From experience gained with more than 1,000,000 miles of revenue freight-train operation, 15 new gas-turbine electric locomotives now under construction for the Union Pacific Railroad will differ in certain respects from the previous ten. The turbine air inlet will be located in the roof. Cooling air for the electric apparatus will be passed through air cleaning blowers. Modifications in the turbine design are expected to give longer life of major combustion components. The control system will be arranged to permit exciting the traction motor fields from the auxiliary diesel generator, allowing the turbine to be shut down during dynamic braking. These locomotives represent the latest development of this new form of railroad motive power.

A 420-hp 40-ton diesel-electric mine locomotive which employs "scrubbing" to reduce exhaust temperature; dynamic braking is used also

Single-Phase Mercury-Arc Rectifier Equipment. After extensive tests and studies, construction is now proceeding on 100 multiple-unit cars and ten 4,000-horsepower locomotives for the New Haven Railroad. This equipment will operate on either 11,000 volts single-phase alternating current or 650 volts direct current.

Diesel-Electric Mine Locomotive. A 420-horsepower 40-ton diesel-electric locomotive for underground service was built in 1953. The exhaust gas conditioning system makes use of "scrubbing" by means of water tanks to reduce the temperature of the engine exhaust from 1,000 degrees Fahrenheit to 160 degrees or less. Provision is made for dynamic braking to control the speed of trains on descending grades.

PRODUCTION AND APPLICATION OF LIGHT

During the year there were a number of outdoor installations using the new high-current Rapid-Start fluorescent lamp. Designs for streets, bridges, and building fronts were notable for the foot-candles, comfort, and appearance achieved.

Indoors, "comfortable" industrial lighting caught on. Units with increased shielding, increased upward light, and with light-colored outside finishes were used. Large-area office-type systems were tried also. There were new kinds, finishes, and forms of material made available in these louverall and luminous ceilings; the materials could be combined or used interchangeably in certain of these "systems." These trends were apparent also in the design of some of the individual units.

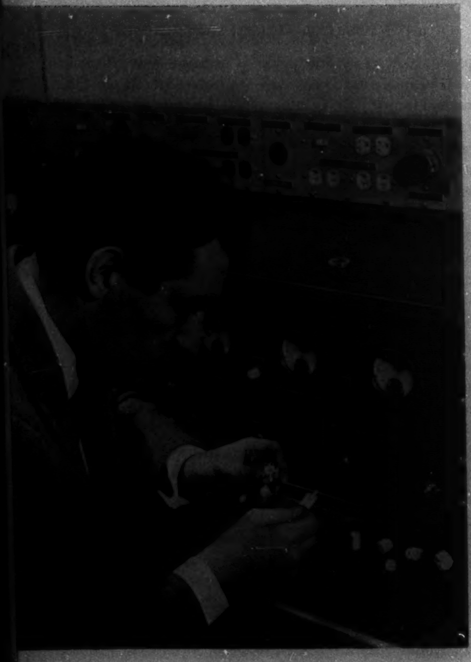
Countless changes were made to improve the performance and utility of existing lamps and there were new ones, too. A neon-argon lamp used to record data on 35-millimeter film is claimed to be the world's finest. Fifty lined up side-by-side cover just 3 inches. Two filaments were tucked into a new flashlight lamp so that a flood or a spot of light can be had with the flick of a switch. A new photoflash one-fourth the physical volume but as effective as older "midgets" was announced. Its base has no pins—just slips in without twisting or fumbling. Size caught up with aircraft landing lamps, too. Jet wings are too shallow for

(Continued on page 18)

1953

A photographic record of some of the important electrical engineering achievements of the year

Courtesy Raytheon Manufacturing Company



▲ Grid magnetron permits greater efficiency and control in the transmission of power. This montage features a cutaway section of this new tube which holds promise of many applications impossible with the present magnetron tube

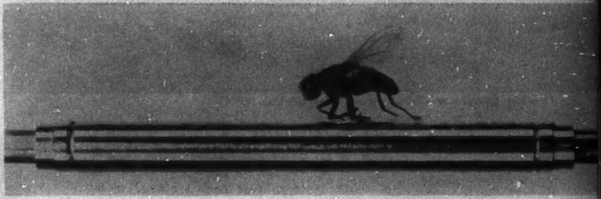
◀ Dr. D. A. Jenny, of the RCA Research Center, examines several experimental types of transistors designed with special cooling fins or liquid coolant tanks. Laboratory tests show they can be operated at 1 watt as compared to about 5/100 watt for smaller uncooled transistors

▶ The Central Radio Propagation Laboratory, National Bureau of Standards' vhf and uhf antenna installation on the summit of Cheyenne Mountain, Colorado Springs, Colo., used in basic tropospheric research on effects caused by diurnal and seasonal variations, terrain factors, and meteorological conditions on propagation between air-to-air and air-to-ground terminals at distances from well within to far beyond line of sight

Vol. 73
1953

ENGINEERING DEVELOPMENTS

▲ Low K. Lee, director of Stanford Research Institute Air Force program on development of techniques for automatic fabrication of electronic subassemblies, holds etched circuit base plate and completed subassembly. Prefabricated components (right), with base plate (foreground), each machine-attached in 0.4 second, ready for frame mounting and insertion of shielded tubes



▲ Transistor repeater developed by Bell Telephone Laboratories for use in the coaxial cable transmission system, shown here with an ordinary housefly for size comparison

▶ Tiny silicon alloy junction diode, developed by Bell Telephone Laboratories, compared to conventional 2-element vacuum tube. Its back leakage is only about 10^{-10} ampere, it requires no warm-up period, operates well under high temperature, and its life-span should be almost unlimited. It should make possible tremendous advances in telephone switching systems and many types of computers

▲ Experimental water-cooled germanium rectifier developed by Westinghouse Electric Corporation. Its germanium wafer—7/8 inch in diameter and 0.015 inch thick—delivers 200 amperes (average) direct current at 100 volts. Expected peak back voltage about 110 volts and forward voltage drop at 200 amperes average (600 amperes peak) about 0.8 volt

▶ The extremely pure germanium needed for transistors can be quantitatively analyzed for impurities using the activation analysis method. An irradiated ingot of purified germanium is being diced in a dry box of the Sylvania Research Laboratories to confine the small amounts of radioactive dust. Impurities of the order of 1 part in 100,000,000 can be measured

ol. 73
953

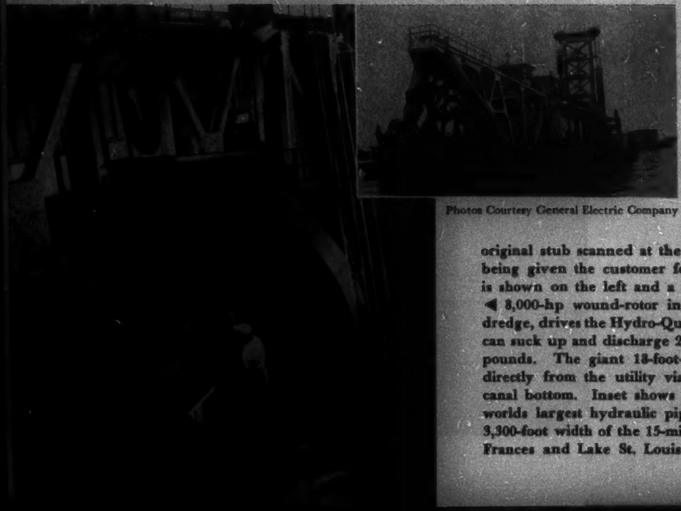
Courtesy International Telephone and Telegraph Co.

Courtesy Westinghouse Electric Corporation

▲ Two 10,500-hp d-c motors, the largest capacity single-armature motors yet built, power the Navy's largest fastest ice breaker ◀ The sequence switch interlocking system moves traffic faster, more dependably, and with a wider safety margin for crews and passengers

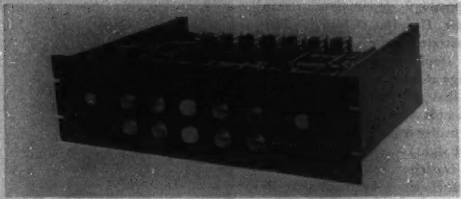
Vol. 73
1953

ACCOMMODATIONS READY FOR SALE



Photos Courtesy General Electric Company

▲ Intrafax facsimile has been adapted, through the co-operation of Western Union with the Pennsylvania Railroad, for transmitting Pullman reservation coupons between the central bureau and branch ticket offices or to the transportation offices of companies requiring large numbers of such accomodations. When handled by telephone, these operations were subject to errors and confusion by manual copy methods obviated by the facsimile system. The electronic reproduction furnishes exact copies of the information on the original stub scanned at the central bureau, the finished facsimile copy being given the customer for use on the train. The Pittsburgh office is shown on the left and a close-up of the Desk-Fax in use on the right ◀ 8,000-hp wound-rotor induction motor, the largest ever used on a dredge, drives the Hydro-Quebec's single-suction centrifugal pump which can suck up and discharge 28-inch glacial boulders weighing up to 1,500 pounds. The giant 18-foot-diameter motor receives its power supply directly from the utility via a 4,000-foot submarine cable laid on the canal bottom. Inset shows an over-all view of the Hydro-Quebec, the worlds largest hydraulic pipeline dredge, which is clearing the entire 3,300-foot width of the 15-mile-long Beauharnois Canal between Lake St. Frances and Lake St. Louis in Quebec, Canada to a depth of 35 feet



▲ Conelrad control center, developed by the Columbia Broadcasting System and produced by Gray Research and Development Company, can prevent enemy aircraft from finding American cities by "homing in" on radio broadcasts by automatically switching from one station to another at random intervals from 5 to 40 seconds

▲ The card translator, Bell Telephone Laboratories' automatic toll-call router, now installed in key offices as another big step toward national subscriber long-distance dialing

ol. 73
1953

▶ Automatic error tester measures and records either electrical or receiver error for all types of synchros. Components of the system (here determining receiver error) are nulling detector, recorder, rotating drum tester, and phase-sensitive detector

Photos Courtesy
U. S. Naval Ordnance Laboratory

▶ Tiny magnetic decision element for high-speed computing machines is essentially a half-pulse magnetic amplifier—the dual unit shown (which often can replace the two vacuum tube stages beside it) weighs 1/5 ounce, consumes 1/4 watt per unit, and has a 1/4-cubic-inch volume

Courtesy General Electric Company

(Right) High-voltage test service car rented with an operator to utilities and industrial plants for high-voltage proof tests and locating cable faults. (Lower extreme right) The U. S. Navy Harbor Defense Underwater detection systems are more efficient, economical, safer, and easier to install even by inexperienced personnel with new submarine cable. (Lower right) Close-up of cable which has from one to 16 copper conductors (depending on the type of underwater detection device) protected by strips of Bakelite polyethylene in the space between the conductors, covered with more polyethylene whose dielectric properties permit higher voltages to be carried with lower signal loss, and two jackets of Vinylite resin compound separated by a layer of armor wire

Courtesy Bakelite Company

▼ Selsyn generator "brains" electrically synchronize standard movie cameras modified for 3-D projection. Here two operators are lining up General Electric selsyns to keep the stereoscopic projectors in unison. It is also easy to change back to standard feature projection with this equipment

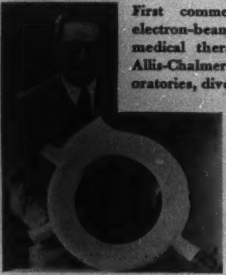
▼ Project Tinkertoy (PT), developed by the National Bureau of Standards for the Bureau of Aeronautics, completes electronic subassemblies with numerous inspections. Inset—Communication Measurements Laboratory Type PT-1000 kit for developing prototype equipment in PT modular form

(Left) Dr. F. H. Squire, chairman, roentgenology department, Presbyterian Hospital, Chicago, Ill., demonstrates the fluoroscopic image amplifier, which produces an image at least 200 times brighter than that on the conventional fluoroscopic screen, in the Westinghouse trailer on nation-wide tour. (Upper right) Microminiature-tantalytic capacitor, having the smallest actual size—here compared to a wooden match head—for the ratings involved, possesses volumetric advantages per volt-microfarad over most other electrolytics, features long shelf and operating life, wide temperature range (−20 to +50 degrees centigrade), and low leakage current. It is designed for low-voltage d-c applications such as hearing aids to eliminate interference and provide a quality tone. (Lower right) Deodorizing 4-watt 110-volt lamp emits 40 to 50 per cent more ultraviolet radiation and thus converts more oxygen into ozone. The fixture facilitates circulation of air

Courtesy General Electric Company

Courtesy Sylvania

Medical



First commercial 22-million-volt electron-beam betatron tube for medical therapy, engineered by Allis-Chalmers and Machlett Laboratories, diverts high-energy electrons from the betatron's magnetic accelerating field by a laminated permendur shunt inside the tube and exits them through a beryllium window. The electrons are absorbed so all destruction ceases at a definite depth, which is controlled by varying the initial electron energy from 5 to 22 megavolts

▲ Torso-shaped models with conducting fluid inside and contacts projecting from the fluid to the outside with auxiliary equipment to measure and record the potentials produced by a current dipole that is an analogue of the heart. These electrocardiographic investigations are being conducted by Dr. Ernest Frank, University of Pennsylvania

Courtesy National Bureau of Standards

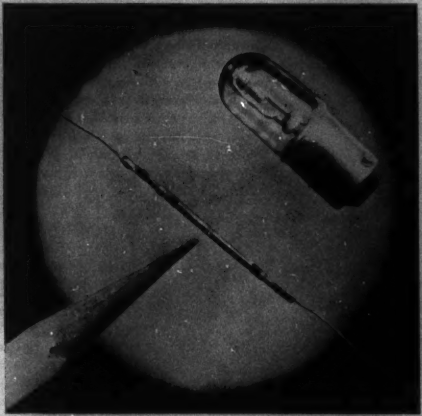
▲ X-ray scintillation spectrometer provides detection efficiency over 80% with energy resolution over 10% in the X-ray energy range from 1/2 to 50 million volts, using a thallium-activated sodium-iodide crystal in which X-ray photons interact until absorbed

Lighting

▲ New Westinghouse 2,500-watt short-arc mercury lamp has a smaller electrode, whose life is lengthened by a factor of 3 or 4, and its light output holds up better

▶ First commercial installation of General Electric fluorescent light dimming system, which is said to have higher efficiency over the dimming range, lower operating costs, and better color control than filament lamps

▲ Panelescent lighting by Sylvania, first used commercially in radio clocks, employs electroluminescence—the creation of light by excitation of a special phosphor

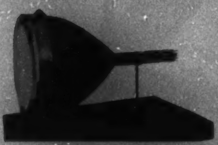


▲ This Westinghouse neon-argon "lamp" the size of a pencil lead is perhaps the world's tiniest lamp. Fifty are put in front of moving 35-mm film to record laboratory data

▼ Largest single application of fluorescent street lights west of the Rocky Mts., General Electric Form 206 luminaires give Seattle's new Viaduct almost glareless light

▼ R-57 800-watt Westinghouse reflector lamps give a foot-candle reading of 33 maximum and 26 average in this Northwest Airlines' main repair hanger in St. Paul, Minn.

Radio and Television



◀ CBS-Colortron is an aluminized direct-view tricolor picture tube. The assembly's simplicity results in low cost and enhances the operational quality. The phosphor-dot screen is on the inside surface of the spherical face plate

Mackay Radio

Courtesy International Telephone and Telegraph

▲ Lifeboat manually powered radio transmitter-receiver sends automatic alarm and SOS on 500 kc alternating each minute with SOS and 30-second dash on 8,364 kc. Receiver works on 8,266 to 8,745 kc

Courtesy National Broadcasting Company

▲ Soundproof control room off-stage at the RCA NBC color television studio in the Colonial Theatre, showing members of the production staff

Courtesy Motorola, Inc.

▲ Cordless "Handie-Micro-Talkie," 1 3/4 by 5 1/4 by 15 inches ties into public address system through a receiver tuned to the same frequency

Courtesy Radio Corporation of America

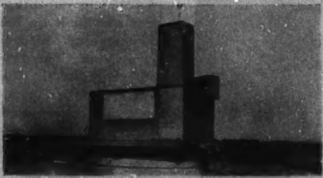
▲ W. D. Houghton and Dr. H. F. Olson with equipment for recording and reproducing black-and-white and color television and sound signals on magnetic plastic tape

▲ Compact dry-type transformer by Westinghouse to be used in the modulator for testing radar thyratrons

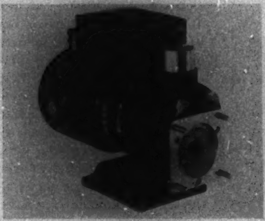
▲ Studio 31, one of four huge Columbia Broadcasting System Television City, Calif., studios which incorporates every electronic and technical advancement in telecasting

▲ Microwave television relay produced by Raytheon Manufacturing Company in both portable and semipermanent models, for relaying on-the-spot signals to the studio

Aeronautics



▲ Turntable radar set provides the U.S. Air Force with single-site ground-controlled approach facilities capable of turning through a 340-degree arc in less than $3^1/_2$ minutes

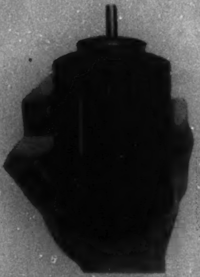


▲ Explosion-resistant air-cooled $3^1/_2$-hp hydraulic pump motor for jet bombers. Rated at 7,500 rpm, this General Electric motor circulates air from −65 to +135° F near 50,000 feet. (Upper right) High-altitude miniature d-c motor for jet bombers is about the size of an ordinary ink bottle, weighs about 8 ounces, and rated at 0.002 hp at 6,500 rpm by General Electric. (Lower right) Rain-protected Westinghouse aircraft alternator. (Left) Automatic Master Sequence Selector (AMSS) developed by Minneapolis-Honeywell Regulator Company for U.S. Air Force can control the takeoff, prescribed course flight, and landing without a human hand on the controls. Inset shows tape-punching machine in use

Device for training one man to become proficient as radar operator, bombadier, and navigator without actual flight. (Upper left) Instructor-director sets up problem, which can include ground-based radar beacon signals and enemy jamming effects, from his control console containing all flight controls and instruments to "fly" the "simplane." (Lower left) Trainee works on a typical problem in one of several booths permitting multiple training. (Right) Simplane with its "sontenna" (simulated radar antenna) extending into tank of purified water kept at a constant temperature to maintain a scale of 1 to 200,000 on a special map of an area for a specific flight

Photos Courtesy U. S. Air Force

Motors



◀ New miniature business machine induction motor provides a quieter, sturdier radio-interference-free drive. This General Electric development is suitable for use in typewriters, adding machines, calculating machines, small bookkeeping machines, recorders, and other similar products. The new motor is expected to meet the size, voltage, and frequency requirements of 95 per cent of the business machine industry

◀ 135-megawatt turbogenerator built by the Westinghouse Electric Corporation. This 245-ton generator is the biggest "power package" ever transported as a completely assembled unit. It was lifted on two overhead cranes and then transported on the world's longest railroad car especially constructed for such loads. It produces enough electricity to light a city with over 250,000 homes

▲ 83,000-hp motor—the world's most powerful—shown during Westinghouse tests for the U. S. Air Force. It is to be operated in tandem with its twin and two 25,000-hp motors to make up a 4-motor drive for supersonic and transonic wind tunnels

(Above left) Largest explosion-proof, totally enclosed, nonventilated continuously rated motor ever built by Westinghouse. This squirrel-cage motor develops 70 hp at 1,180 rpm and can produce 90 hp for an hour. It can be operated on 220- or 440-volt power as it is designed for use with an a-c continuous coal-mining machine (Above right) Tri-Clad "55" motor, called sonant due to its greatly reduced noise level, offers better protection and less maintenance time while retaining the rigid cast-iron frame and stator construction. This General Electric motor is lighter, smaller, has an improved bearing assembly, better ventilation and insulation systems

◀ One of four General Electric stators for Moffett Field, Calif., to create supersonic air blasts for aircraft and guided missile design. They generate a 216,000-hp maximum—the greatest load ever concentrated on 1 shaft.

▶ World's largest totally enclosed gas-filled induction motor here driving a centrifugal compressor in Esso catalytic cracking plant. General Electric's 14-ton motor is rated at 3,000 hp, 1,800 rpm, 2,300 volts, 3 phase

Courtesy Sylvania Electric Products, Inc.

Courtesy Raytheon ManufacturingCompany

Industry

(Above) Fast heating qualities of gold-lined 1,550-watt infrared lamp are incorporated in the Kenmore electric kitchen range now available commercially. The bulb is mounted in a metal reflector and covered by a red glass cover. Both the bulb envelope and the covering plate are of Vycor glass which resists extreme temperature changes without cracking. (Upper right) Ultrasonic tool employs a 27-kc frequency to cut quickly difficult shapes to fine tolerances in glass, porcelain, and hard metals. (Right) The Betamatic is an automatic basis weight controller which maintains the paper to the desired grade. It is actuated by beta rays from radioactive isotopes, which after absorption in the sheet are detected by ion chamber detector and amplified electronically to operate a pen recorder or control circuit. (Below) Patwin electropolarizer utilizes polarographic method of analysis saving half the time used by chemical analysis of plating solutions. General Electric alnico-magnet galvanometer measures the low values of current or voltage. (Bottom) Fillerarc, new equipment for consumable-electrode gas-shielded welding, permits doubling of output on applications where filler metal is added. Wire drive unit, welding gun, and welding generator are shown

Courtesy Isotope Products Ltd.

Photos Courtesy General Electric Company

▶ New general-purpose radiant heating furnace is a horizontal single-batch type with built-in quench which can be fired by gas or electricity, and used with any of the standard atmospheres. Only one operator is required as loading and unloading only are performed manually. Furnace temperatures up to 1,850 degrees Fahrenheit are possible, and hourly output is from 200 to 400 pounds depending on sizes and shapes. The furnace can be used for bright hardening, carbonitriding, carburizing, Martempering, normalizing, nitriding, or stress relieving

Courtesy Westinghouse Electric Corporation

Courtesy International Business Machines

Computers and

Courtesy National Bureau of Standards

▲ Electronic data processing machine "701," composed of 11 compact and connected units, is the first calculator of comparable capacity to be produced in quantity. It can be rented by the month—being installed, operated, and maintained by a trained crew—or problems brought to IBM

▶ Brig. Gen. L. I. Davis checks the OARAC digital computer containing operations panel and high-speed input and output tape mechanisms flanked by rows of plug-in turrets with 1,400 tubes and 7,000 diodes

◀ Rapidly replaceable standardized plug-in circuitry units promise reduced manufacturing and repair costs and improved reliability

Courtesy General Electric Company

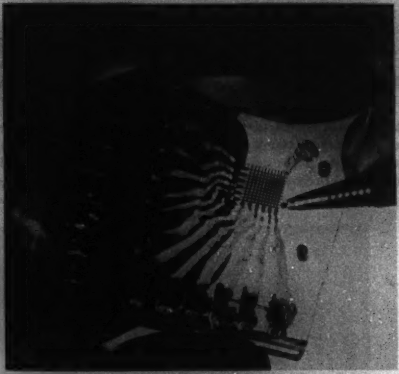
New "Speed Tally" developed by Remington Rand Inc. uses a key-punch and electronic computer to tally orders or inventory items. Within 0.4 second it adds the new item to the existing total in the proper catalogue classification, and registers the new total. It can handle 13,000 items in each of three categories. Girl at key punch tallies orders which "electronic brain" (see inset) processes

Vol. 7
1953

Vol. 73
1953

Memories

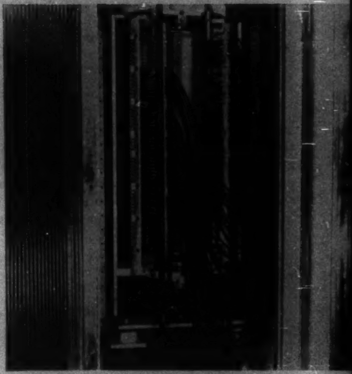
Courtesy Raytheon Manufacturing Company



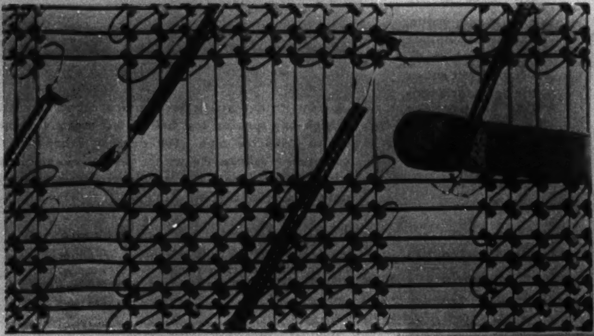
Courtesy Bell Telephone Laboratories, Inc.

▲ Engineer adjusts magnetic memory tape feed behind frame of high-speed electronic digital computer Raydac, designed for the Navy study of guided missile flights

◄ Magnified view of a tiny barium titanate crystal a few thousandths of an inch thick and 1/4 inch square. These crystals can "remember" bits of information indefinitely. Note fine electrodes which carry data, as electric charges to crystal



▲ Magnetic drum auxiliary memory, recently added to SWAC (National Bureau of Standards Western Automatic Computer) reduces access time per word to 500 microseconds—about 1/30 second. This is done by transferring numbers in sizable blocks stored sequentially on the drum's circumference

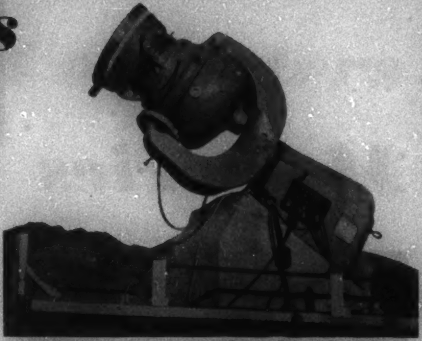


Dr. J. A. Rajchman examines experimental memory device with 10,000 tiny magnetic cores. He developed it at the Radio Corporation of America David Sarnoff Research Center to provide a high-speed large-capacity memory to help solve problems too vast and complex for present computers. Inset shows an enlarged view of a section of this device compared to a paper match head. A core "memorizes" one bit of information in a few millionths of a second when both horizontal and vertical wires through its center carry an electric signal. The common wire threading through all cores "reads out" an electric pulse that may be created when an individual core is interrogated. Insulated wires, the dark diagonals, link the common "read-out" wire of one group to another

Measurements

Courtesy National Bureau of Standards

▲ Electronic gauge rapidly and inexpensively gives the thickness of all types of metallic coatings differing appreciably in conductivity from the base metal. This portable and direct-reading device essentially tells the relative strength of the eddy current induced by a high-frequency current without destroying the specimen



Courtesy Eastman Kodak Company

▲ Precision electric drives and controls on new telescope-camera enable Harvard astronomers to photograph meteors, whose paths on special curved film become dotted, and to find their speed by interrupting light with a rotating shutter. Rotary switch times 12-minute exposure and the camera's position

◀ Largest dynamometers ever used for axle-testing. Test stand is in foreground, an output dynamometer on left and input one on right. This General Electric machine can exert speed, torque, or load to simulate actual road conditions. Inset shows the operator's console at left and the cycling control panel with two strip chart recorders at right

Courtesy Westinghouse Electric Corporation

▲ New steam division development laboratory with a high-bay turbine test hall to test steam turbines up to 1,500 psi and 1,100 degrees Fahrenheit, a compressor laboratory with a 60-foot closed-circuit wind tunnel, and laboratories for aerodynamic development of blading and gas-turbine combustors

Photos Courtesy U. S. Naval Ordnance Laboratory

(Left) Automatic equipment for measuring force and moment during wind tunnel tests shown with B. D. Gilbert and E. J. Winslow. In center foreground console starts tunnel blow. Inset shows 3/4-inch electric pressure gauge consisting of two small beryllium-copper diaphragms fastened to opposite sides of the ring to form a vacuum-tight chamber. Atop the cell is one of 4 strain gauges which form a Wheatstone bridge. (Below) Greatly improved flame-retardant insulation has a paper base impregnated under heat and pressure with a new synthetic resin; it ignites twice as slowly, while flame goes out in 1/4 time of the usual phenolic-resin insulation

Courtesy Westinghouse Electric Corp.

Transformers

◀ Single- and 3-phase power is supplied economically from CSP duplex Westinghouse transformers

▶ 50,000-kva mobile transformer can interconnect a 132-kv line with an 88- or 66-kv system and can step down from 132, 88, or 66 to 44, 33, or 22 kv. This Westinghouse 3-phase unit can be moved with only its lightning arresters taken down; it weighs 90 tons including the coolers

Courtesy General Electric Company

◀ Electromagnetic model and actual core and coils rated 33,333 kva 115 kv to 37,000 Y to 4,160 volts, shown with inventor P. A. Abetti. Model is 1/6 the size, 1/216 the weight of the transformer. It combines the best features of geometrical and equivalent-circuit models and provides complete knowledge of transient voltages and waveshapes in any transformer

▶ 175,000-kva forced-oil air-cooled transformer. Each unit is 70,000 pounds lighter than the one replaced which had less than one-half its capacity

Courtesy General Electric Company

◀ 330-kv circuit breakers with 25-million-kva interrupting capacity under construction by Westinghouse Electric Corporation for the Ohio Valley Corporation plutonium production plant. The interrupter is designed for fault clearing in 3 cycles and reclosing in 15 rather than the usual 20 cycles

▶ 5,000-kva 600-kv single-phase 60-cycle transformer. The unit is built by Allis-Chalmers Manufacturing Company to withstand 600-kv 3-phase transmission-line service with presently available lightning arresters or 880-kv service when suitable protective equipment becomes available

(*Continued from page 3*)

PAR-56 lamps so *PAR-46* lamps with the same candlepower were designed. Cost and convenience considerations led different manufacturers to reduce the bulk of certain rough service and general service incandescent lamps.

New high-wattage mercury lamps appeared. Included was a 700-watt for outdoor lighting, a 2,500-watt photochemical lamp, and a series of them in 2,000-, 3,000-, and 4,000-watt ratings.

Progress with fluorescent auxiliaries was highlighted by the introduction of packaged electronic dimmers for Rapid-Start lamps and by improvements in the design of static high-frequency inverters. Certification by Underwriters Laboratories and Electrical Testing Laboratories was achieved for Rapid-Start ballasts complying with specifications. Indicative of the increasing use of fluorescent lamps as components in other equipment was the introduction of inexpensive, nonenclosed, clamped-core ballasts for these applications. Other pictures of some of these developments appear on page 9.

Fine machining is done in this plant of L. L. Constantin Company, Clifton, N. J., under 75–80 foot-candles from fluorescent lighting

Industry

CHEMICAL, ELECTROCHEMICAL, AND ELECTROTHERMAL APPLICATIONS

Among the developments which directly affect the petroleum industry, very large a-c motors of the order of 3,000 horsepower have been made with explosion-proof construction features. These motors are particularly suited for application in hazardous locations met in oil refineries and on pipe lines.

Considerable progress has been made in the application of microwave systems and equipment for communication purposes and for the remote control of unattended pipe lines.

In the general chemical, electrochemical, and electrothermal industries, cathodic protection, as a method of corrosion control for underground structures, has had a widened range of application. The underground structures of several electric power plants recently have been placed under this form of protection as well as many miles of pipe-line systems, gas distribution systems, water tanks, and other equipment. Joint cathodic protection programs have been established for the mutual benefits of several organizations having property in the same area. Equipments suitable for use in low-energy circuits of cathodic protection systems have been developed and are being applied.

Heavy-duty fluorescent units of aluminum and weather-resistant plastic can be swung over a parapet for maintenance

In the production of steel, much progress has been made in the use of the electric arc furnace as a tool for the production of normal grades of carbon steel. Furnace sizes continue to increase and equipments capable of tapping a 150-ton heat are coming into use in the industry. Such large furnaces are powered by electric equipment rated at 36,000 kva. Because of the magnitude of power required, these large furnaces are being placed more and more on systems having service voltages in excess of the 15-kv class. This has been wholly responsible for the development of a special compressed-air furnaces circuit breaker offering construction features which permit repetitive operation interrupting normal and magnetizing currents and at the same time having capabilities of interrupting circuit faults up to 500,000 kva.

FEEDBACK CONTROL SYSTEMS

Simulator for Autopilot Design. The time needed to design autopilots has been cut extensively by the use of a flight simulator. The initial design is carried out completely on a computer. Then components are designed and substituted in the flight simulator. Therein lies the most recent improvement—the simulator as now used has everything but wings and an engine.

An electronic computer reports the aerodynamics of flight. The rest of the system is exactly that of the airplane, down to the linkage mechanism of the pilot's controls.

The newly designed flight platform and the altitude simulator make this second phase possible. The flight platform consists of a table that will roll, pitch, and yaw just as the actual airplane does in flight. Gyros that control the autopilot are mounted directly on the table.

The altitude simulator, as described by the electronic computer, actually reproduces effective pressures as the simulated airplane flies. These new improvements allow the use of all the autopilot sensing devices, so that the complete autopilot system is reported. Thus, such variables as hysteresis, threshold sensitivity, and nonlinearity of the measuring and sensing devices can be taken into account.

The final phase of the autopilot design is the actual flight test. With the aid of the flight simulator, any trouble that occurs can be diagnosed and cured quickly.

Advanced Flight Control System. A new concept in flight control is embodied in the recently announced flight control system *FC5*. Instead of "adapting" a standard autopilot to a completely designed airplane, the *FC5* is applied to the airplane during the early design stages. In this way the *FC5* can be "tailor-made" to meet the high performance characteristic of aircraft which will go into production beginning in 1955. The results of such an integration of autopilot and airframe design are a considerable saving in size and weight and an improvement in performance and reliability.

The *FC5* is an advanced system and represents major improvements over the currently successful systems now in production. Integration of the airframe-autopilot maneuvering controls eliminates the separate autopilot maneuvering controller and the parallel actuators. Maneuvering is accomplished through the pilot's manual control stick and the airplane's feed system. Actuator travel is limited to prevent inadvertent "hardover" control surface movements. Other advanced design techniques include subminiaturization with etched wiring, use of magnetic amplifiers, and actuator design to meet 250-degree-Fahrenheit continuous ambients at all altitudes.

The *FC5* is now ready to be integrated into aircraft designs for 1955 production.

Integrated Electric Control. The first integrated electric control for turbojet engines permits complete turbojet engine operation by a single lever. This control, in production for use with the *J47* engine, regulates main fuel and afterburner fuel and controls exhaust nozzle area to achieve optimum engine performance. This is the first production electric control, for an engine with afterburner, in which all engine functions have been integrated. A single lever sets the power level for all flight conditions and necessary adjustments of fuel flow and nozzle area are made automatically.

Compressed - air circuit breaker for arc furnace service

Specially designed lighting fixture assembly made of aluminum alloy having a curvature on the housing which contacts the ceiling grid. The resultant high heat conduction carries off heat from lamps and so reduces load on air-conditioning system

INDUSTRIAL POWER SYSTEMS

As the result of its experience in wiring of plants built since the war, the Aluminum Company of America (Alcoa) has designed an all-aluminum electric system for its recently completed Pittsburgh, Pa., home office. There are five features in the electric installation of the Alcoa Building that are new to office building construction: (1) with minor exceptions, exclusive use of aluminum conductor; (2) exclusive use of rigid aluminum conduit; (3) use of dual low-reactance riser busses; (4) use of an all-aluminum lighting fixture as illustrated designed as an integral and efficient part of the ceiling panel heating and cooling system; and (5) design of a lighting system that can be modified readily to meet changing office arrangements and can provide a lighting level of 35 to 50 foot-candles intensity.

MINING AND METAL INDUSTRY

The most significant development in the mining field is increased automation. A robot mining machine developed by the Carbide and Chemicals Company has extended coal stripping operations where it is too costly to remove the over-burden by conventional means. This machine is designed to burrow under a bank, remove the coal, and convey it to the outside. It is completely controlled from the outside, and means are provided to indicate

Control console for a manual-automatic mine hoist features remote control. In the background is the skip rising in shaftway

continuously the position of the mining head and whether it is cutting coal or rock.

The increased use of automatic mine hoist control is another example of increased automation. The illustration shows the control console of a remotely controlled manual-automatic mine hoist at the International Minerals and Chemicals Corporation, Potash Division, at Carlsbad, N. Mex. The hoist and its auxiliary equipment are located some 125 feet from the hoist man. The control console has the necessary devices for keeping the hoist and auxiliary equipment under complete control.

An interesting development in the metal industry has been the installation of three very large blooming or slabbing mill drives. Each drive is a 12,000-horsepower double-armature twin type with two 3,000-horsepower motors driving the upper roll and two 3,000-horsepower motors forming a separate drive for the lower roll. In addition, two of the mills are provided with vertical edger roll drives consisting of 4,000-horsepower double-armature motors. This is the largest horsepower applied to the main rolls, as well as the edging rolls for such mill drives. Two drives use 40-rpm base speed motors, and one drive uses 70-rpm base speed motors. These huge drives are reversed from base speed in one direction to base speed in the other direction in from 1 to $1^1/_2$ seconds which requires a tremendous amount of forcing on the main generator fields.

Power

CARRIER CURRENT

Microwave Equipment. A new microwave system for utility installations providing 30 voice channels, in addition to service and alarm channels, was put into operational use in 1953. Shown on page 21 is a typical installation of a 2-way repeater, with complete stand-by and automatic transfer, for an unattended repeater station. Included in the assembly shown is a service voice channel, an alarm system for reporting abnormal conditions at the station, and remote control unit to start, run, and shut down the emergency motor generator.

Frequency-Modulation Telephone Equipment. A new design of frequency-modulation telephone equipment featuring full crystal control of the transmitter frequency and high receiver selectivity found service in a number of installations this past year. Provision is made for ringing by either 60-cycle modulation or by frequency shift, both the normal and shifted frequencies being crystal controlled. The basic simplex assembly may be converted to single-frequency duplex operation by the addition of a Voice Switching Unit which contains only high-vacuum tubes and which provides very rapid and quite automatic voice switching. Conversion of the basic simplex assembly to 2-frequency duplex operation is made by the addition of an audio hybrid unit.

Frequency-Shift Audio Tones for Industrial Applications. The functions of telemetering, supervisory control, load control, transferred tripping, and protective relaying as well as teletype, ringing, and dialing may be performed over microwave or radio channels by means of a new design of frequency-shift audio-tone equipment. These tone units were designed primarily for these industrial applications and feature many of the circuit refinements that have been developed for carrier-current equipment designed for performing many of these same functions. Physically the units feature a single rack unit drawer type of construction that provides an exceedingly high degree of accessibility for servicing and adjustment for a very compact assembly.

High-Speed Frequency-Shift Tone Equipment for Transferred Trip Protective Relaying. This development provides equipment basically intended for use on utility microwave systems to provide multiplexed transferred trip channels. Four tone channels may be applied to a normal voice subcarrier. Each frequency-shift tone channel is capable of independent operation and has a maximum transmission delay including input and output relays of 10 milliseconds. A portion of this development consisted of a differential trip-block circuit capable of supervising individual tone channel levels and individual channel signal-to-noise ratio. This channel supervision, an integral part of each tone receiver, is capable of blocking receiver output whenever the tone signal level or signal-to-noise ratio falls outside of preset limits. The blocking operation is performed with such speed that the tone channel is incapable of acting upon a substandard signal before its output is blocked. An optimum compromise between speed, reliability, and security has been achieved in this design.

Differential Channel Supervising Equipment for Frequency-Shift Audio Tones. A differential squelch circuit has been developed for use with audio-frequency carrier. This frequency-shift tone equipment, capable of providing 18 telegraph channels in one voice channel, now can be securely protected on an individual channel basis. The differential squelch circuit is capable of supervising signal level and signal-to-noise ratio and will provide for channel disconnection and alarm when signal quality deviates beyond preset limits. The attack time of this development is less than one-half the operating time of the tone channel, making it possible for it to disconnect the output circuit of the tone channel before erroneous information appears on these terminals. Signal-to-noise limits are maintained on the differential squelch circuit even though tone signal levels vary as much as 20 decibels. The device has provided excellent security when applied to the transmission of supervisory control, load control, and critical telemetering signals over many communication media.

INSULATED CONDUCTORS

During the year there continued to be considerable interest evidenced in the problems associated with the use of aluminum for the conductor and sheath of insulated cable. Progress reports appeared on long-term investigations in which the underlying objective is to provide factual information on the fundamental factors involved in the design and selection of fittings and connectors for use with aluminum insulated conductors. A useful reference on the subject of insulated aluminum conductors was made available in the form of a publication entitled "Symposium on the Use of Aluminum in Insulated Conductors."*

Progress was made during the year on various methods of application of aluminum as a sheath to insulated cable. Several commercial installations of high-voltage impregnated-paper cable with aluminum sheath (applied by pulling the insulated core into an oversize pre-extruded length of tubing and then subjecting the latter to a sinking operation) were placed in service in Canada.

Several high-voltage submarine cable projects involving transmission distances up to 60 miles were underway or in the planning and prototype stage at the close of the year.

A sound understanding of the basic fundamentals involved in the determination of the temperature rise and current-carrying capacity of underground cable systems under cyclical loading is necessary if full advantage is to be taken of the load capabilities of such systems. The results of a 3-year investigation into the problem, as reported in a symposium presented during the year, provides a notable advance in methods and assurance of performance calculations made for such conditions. An important but not thoroughly understood phenomenon has emerged in the investigation of the thermal resistivity of the soil, another factor of major importance in the economical loading of underground facilities. Observational data accumulated over the past few years indicate instability of soil thermal resistivity in some locations under certain conditions which are apparently related to soil type and to moisture migration characteristics. Consideration is being given to the possibilities of laboratory research on the subject to permit isolation and control of the variables involved.

POWER GENERATION

An outstanding development in power generation concerns the recent announcement by American Gas and Electric Service Corporation to construct a 120,000-kw unit at Philo, Ohio, which will have a supercritical throttle steam pressure of 4,500 pounds per square inch gauge—1,150 degrees Fahrenheit initial temperature and two stages of reheat at 1,050 and 1,000 degrees Fahrenheit respectively. The drumless steam generator will be of the once-through type. The net plant heat rate is expected to be approximately 8,500 Btu per kilowatt-hour.

Anaerobic control of marine growths in conduits handling salt water for steam plant circulating water systems has demonstrated its economy and effectiveness.

In the atomic power field, a highlight was reached in the release by the Atomic Energy Commission of the results of studies by four industry teams on the application of nuclear reactors to the generation of electric energy. The studies are published in a pamphlet, "Nuclear Power Reactor Technology" (Superintendent of Documents, United States Government Printing Office, Washington, D.C., 25¢).

Several outstanding hydroelectric developments are approaching completion, notably the Sir Adam Beck–Niagara Generating Station number 2 of the Hydro-Electric Power Commission of Ontario, with its two 51-foot rough diameter, 45-foot finished diameter tunnels; and the Nechako-Kemano-Kitimat development of the Aluminum Company of Canada Limited.

Initial work was begun on a major Canadian pumped-storage scheme associated with the Sir Adam Beck–Niagara Generating Station number 2, whereby the excess water available during certain periods of the day and year from Niagara Falls, under the treaty, will be utilized during peak-load periods.

Several electronic excitation systems for steam turbine generators were placed in operation. These co-ordinated excitation systems are composed of a sealed-tube ignitron rectifier with static magnetic generator voltage regulator and associated switchgear and protective equipment.

Operation of fully loaded generator at leading power factor during light-load system conditions has been reported. Confidence for underexcited operation results from the ability to calculate accurately and predict the increased steady-state stability limits of synchronous generators utilizing static magnetic regulators with static or rotating amplifiers.

ROTATING MACHINERY

Several large hydrogen-cooled alternators have been installed during 1953 which employ new cooling systems where the cooling medium is in direct contact with the conductors. Two are rated at 90,000 kw and one of these has direct cooling of both the rotor and stator conductors.

Typical installation of 2-way repeater with stand-by and automatic transfer for use in an unattended repeater station

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* AIEE Special Publication *S56*, November 1953.

It is expected that these new cooling systems will allow the design of machines up to 250,000 kw.

A 20,000-kva air-cooled low-reactance synchronous condenser having grain-oriented stator laminations and cooling fins around the entire surface of the field coils was placed in service. This improved field coil design allows up to 20 per cent reduction in frame size for the same temperature rise.

The most significant development in induction motors has been in the smaller general-purpose ratings. Several companies have announced new motor lines in accordance with the suggested standard for future design adopted by National Electrical Manufacturers Association last year. By using newly developed materials, such as Mylar insulation, and better designed ventilation systems it has been possible to obtain reductions in volume of 50 per cent and in weight of 35 while maintaining usual values of efficiency, temperature rise, torque, and so forth.

Two slabbing mills have been installed in 1953, each driven by two 6,000-horsepower quick reversing d-c motors. These are the largest electrically driven slabbing mills in service and are a major advance in the elimination of steam power in steel mills. The two cold strip mills in the Fairless Works are also of record size. There is an 80-inch 4-stand cold strip mill powered by d-c motors totaling 21,650 horsepower which operates at 3,030 feet per minute and a 30-inch 5-stand tinplate mill which operates at 7,000 feet per minute. Both mills have more power and higher speed then previous installations.

The year 1953 saw the first large-scale usage of "mica paper" in rotating equipment. There are now approximately 2,500 transportation-type motors and generators in service which are insulated with mica-paper glass-cloth tape. This tape is more uniform and more flexible than conventional mica insulations and all raw materials are available in the United States.

SWITCHGEAR

Power Circuit Breakers. Two factories have developed 330-kv oil circuit breakers having 25,000,000-kva interrupting capacity. These circuit breakers are rated 1,600 amperes continuous, 3 cycles interrupting time, suited for fast reclosing service, and are insulated for 1,175-kv impulse withstand test. The breakers use a common pneumatic mechanism and each phase is mounted in a watch-case-type tank. The accompanying right-hand illustration shows a single pole of one of these circuit breakers.

A new oil-pressure-operated mechanism for control of high-voltage oil circuit breakers and providing a very fast automatic reclosing has been developed by manufacturers.

Air Break Switches. Several American factories have developed a new 1,600-ampere disconnecting switch for 330-kv service to be used with the new 330-kv oil circuit breakers. Severe problems associated with corona shielding and mechanical strength have been overcome satisfactorily according to technical papers describing these new designs.

A new line of enclosed interrupter load-break high-voltage outdoor disconnecting switches has been developed and ratings up to 161 kv are now available. The circuit is interrupted by quick-break contacts in a chamber filled with sulphur hexafluoride. The switch is suited for switching long transmission lines, transformer magnetizing currents, or load current up to 600 amperes.

Switchgear Assemblies. Demands for higher current rating in isolated phase metal-clad bus gear has required the design of bus rated 8,000 amperes.

New methods have been developed for silver-plating aluminum bus at its terminals to permit making up long-life noncorrosive joints in bus used in metal-clad assemblies.

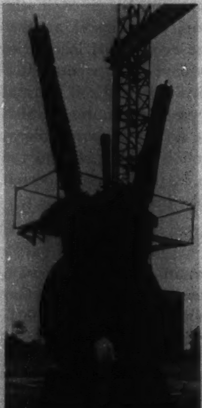
Automatic Circuit Reclosers with increased nominal current ratings and higher interrupting capacities were developed. In one case a 3-phase circuit recloser was developed to use a shunt coil to store energy for opening and closing power, in place of the previously used series operating coil.

General. A new flame-retarding insulation in sheet form known as "Self-X" has been developed.

TRANSFORMERS

The first transformers for operation on the 330-kv system of the American Gas and Electric Company were completed. These were autotransformers, rated 150,000 kva, 3 phase, which will be used to tie together the 330-kv and 138-kv systems. One of these large transformers is shown in the illustration on page 23. Generator transformers rated 78,000 kva, 330 to 17 kv, were shipped also. The insulation level of the 330-kv windings is 1,175 kv.

The development of an electromagnetic model enables engineers quickly to obtain complete knowledge in the design stage of transient voltage magnitudes and waveshapes in large power transformers. A model of a 300,000-kva 161-kv transformer has been built and tested and the final transformer design is under way.



One pole of 330-kv oil circuit breaker

A 600-kv transformer tested with 700-kv 60-cycle and 1,600-kv full-wave impulse voltage was completed. It was designed from fundamental data without reference to previous types and was constructed to obtain the answers to several controversial problems in the higher voltage field.

Reduction of transformer noise is the objective of a million-dollar sound-test laboratory under construction at Pittsfield, Mass., for the General Electric Company. A high sound absorption coefficient is obtained by using fiberglass wedges and double-wall construction.

Experimental distribution transformers, using aluminum instead of copper windings, are being produced in a number of ratings and tested in actual service. The over-all weight, dimensions, and electrical characteristics of these aluminum-wound units are practically identical to copper-wound transformers. Also, dry-type current-limiting reactors with aluminum windings that meet all requirements of the American Standards Association standards are being produced.

Oil-filled potential transformers with integral lead terminations have been built in the 115-kv class with considerable reduction in size and weight over older designs. Oil-insulated current transformers of similar construction also have been developed through the 115-kv class.

An essentially inorganic insulation, known as Alpholite, has been developed to replace more expensive, high-temperature resin-bonded structures in dry-type transformers. Based on the discovery of a controllable phospho-asbestos reaction, the compound has found application as phase barriers, cylinders, axial spacers, and core bolt insulation.

Some of these transformer developments are shown on page 17 of the pictorial section.

TRANSMISSION AND DISTRIBUTION

One of the most important developments in this field has been the increasing application of a number of engineering tools which are greatly facilitating the understanding and solution of transmission problems in the laboratory and in the field.

The analogue computer continues to be applied to a wide range of problems. It has proved to be particularly useful in studying the application of surge protection in stations. The application of a miniature impulse wave to the network and the measurement of waveshape and magnitude of voltages at various parts of the system have made possible a much more accurate application of lightning arresters than hitherto had been possible.

Three-phase autotransformer 150,000 kva and 60 cycles rated 330 kv to 138 kv with 13,200-volt tertiary. The insulation level of the 330-kv winding is 1,175 kv

The synchronograph has been developed further and has been used in a number of problems in the field where reduced impulse voltages have been applied to overhead and underground transmission systems, transformers, and substations resulting in obtaining information on reflection and attenuation much more readily and accurately than by calculation.

The digital computer has come into its own by application to transmission and distribution problems and has taken its place along side the network calculator in stability and other studies.

A field of extensive study has been that of incremental transmission losses. The aim of every electrical utility is to dispatch generation so that the system operates at optimum economy. Incremental loss studies have been made and loss formulas developed to achieve this end. These formulas may be used also to advantage in billing which becomes important in interconnected systems.

In the field of distribution, the trend to higher voltages has been evident and has extended into 7.2/12.47-kv urban and up to 23-kv rural systems.

Automatic circuit reclosures are being more generally applied in substations in lieu of the more conventional station-type breakers for distribution feeder circuits. This trend has been stimulated by design changes in reclosures which provide for greater interrupting ability, 3-phase operation, and faster interrupting times.

Studies of wood and steel construction continue to be an active subject with new wood pole lines at 230 kv being put in service and others in the design stages. Studies continue of extra-high-voltage lines and construction is nearing completion of 330-kv lines to be put in service in the near future. An extensive investigation of high-voltage impulse tests was made on a 500-kv transmission line and associated substation equipment. New measuring equipment and techniques were developed in this field.

Science and Electronics

BASIC SCIENCES

In the field of dielectrics, of major importance to electrical and electronic engineers is the availability of magnet wire insulated with a recently developed modified silicone enamel. Accelerated life testing of motors wound with this new class of magnet wire indicates a life expectancy at 180 degrees centigrade comparable to that of identical motors wound with organic resin-coated wire at their maximum operating temperature of 105 degrees centigrade. Thermal stability of this order assures greater overload protection and reliability in such equipment as random-wound integral fractional-horsepower motors, transformers, reactors, control coils, and relays. This wire can be used also to reduce the size without decreasing the reliability of electric machines and electronic components.

In the field of magnetics the development and use of ferrites have continued so that now about 5,000 tons are used yearly in the United States. Ferrites with square hysteresis loops have been prepared using mechanical stress, and are being tried in switching and computer circuits.

In an attempt to save strategic nickel, a workable iron-aluminum alloy (16-per-cent aluminum) has been developed for use in apparatus, such as underwater sound, in which high magnetostriction is essential.

Circuit theory usually is broken down into the branches of analysis and synthesis. The analysis of linear networks has reached a high degree of maturity, and current developments show the increasing use of matrices, the concept of a generalized frequency variable, and simplification of the relationship between steady-state and transient responses. In synthesis much attention is being given to networks having a prescribed steady-state magnitude or angle function. Most of the activity utilizes the analogy between a network function and potential and stream functions in a 2-dimensional field in which zeros and poles of the network function are replaced by line charges.

Network theory recently has been expanded to include the gyrator as a possible circuit element. A gyrator is an element which acts much like an ideal transformer, but for which reciprocity does not hold. Gyrators for microwave circuitry are now in the laboratory stage. A 4-terminal pair which includes a gyrator actually becomes mathematically simpler than an ordinary network because certain restrictions on the network function are relaxed.

Some of the more important advances reported concerning the electrical properties of gases are as follows:

In the field of high vacua it has been demonstrated that pressures as low as 10^{-10} millimeter of mercury can be obtained practically.

The release of electrons by the impact of ions against a cold cathode is now understood in terms of the basic physical processes involved (Auger effect), involving simultaneous displacement of two electrons from atomic levels.

Microwave technique has been used for the measurement of the collision cross sections of gas molecules for electrons, in low-energy gas discharges.

Sputtering at low voltages has been demonstrated to be a momentum transfer problem, as shown by the geometry of the gas atoms causing the sputtering and the pattern of the material sputtered.

In applied mathematics probability is assuming an increasingly important role for electrical engineers. Its applications to problems of noise in electric circuits is well known and has been the basis of several important papers.

Various transistors have been developed during the year. The field-effect transistor, which is a unipolar semiconductor amplifying device, has been reduced to practice and shows promise of considerable usefulness for frequencies of the order of 100 megacycles per second. The technique of lithium diffusion junctions has been developed for the purpose of making good rectifying contacts to p-type silicon. Surface properties of semiconductors have been explored and the role of the surface in practical semiconductor devices partially understood. The preparation and purification of silicon and the group III–group V intermetallic compounds have been studied, with a view to the possible replacement of germanium, for certain applications, by materials of this type, for example InSb.

COMPUTING DEVICES

THE RAPID GROWTH of digital computer power is illustrated by three of its major indexes.

Digital Computer Capabilities	1943	1953
1. Arithmetic operations per second	0.2	30,000
2. Size of high-speed memory (10-digit decimal numbers)	10	2,000
3. Input-output speed (10-digit decimal numbers per second)	1	300

This fantastic increase in power, which is something like the product of items 1 and 2, is just beginning to be assimilated in computer operations.

The doubts of 2 or 3 years ago regarding the eventual reliability of the very-high-speed units have been dispelled. Several computers are turning in an impressive record today on computing problems. The more demanding reliability requirements of critical control functions are close to being met.

Clearly notable today are the paralleling developments of (1) automatic control in which the computer multiplies man's intelligence and speed in controlling the power that does his physical work, and (2) the development of computers and data-processing equipment for his mental and clerical work.

Aids to Man's Work

Physical	Mental and Clerical
a. The Tool, man provides power and intelligence.	*a.* Desk calculator, slide rule, and so forth.
b. Power Tool, man provides intelligence.	*b.* Business machine—processes masses of similar documents.
c. Automatically Controlled Power Tool (includes primitive computing elements.) Example: steel mill drive.	*c.* Large-Scale Automatic Computer. Complete sequences of mathematical or business calculations are manually programmed.
d. Automatic Factor or Process Line. The computer is mature co-ordinating groups of machines and making intricate decisions at high speed.	*d.* Self-Programmed Automatic Computer. Interprets simple commands into extensive programs for science and industry.

During 1953 advanced development and application has centered in field *c*, and research in fields *c* and *d*.

The magnetic core memory has been developed and applied successfully and results to date credit it with substantial improvements in reliability, speed, energy, and space. This is exemplified by the coincident-current magnetic-memory plane shown.

Two classes of computers have become commercially available during the year: 1. The Drum Computer using the magnetic drum as the high-speed storage. 2. The large-scale very-high-speed computer using electrostatic high-speed storage and magnetic drum and magnetic tape accessory storage.

An aircraft flight-plan storage and processing system has been developed.

ELECTRONICS

Marked progress has been made in 1953 in the generation and transmission of ultrahigh-frequency (300–3,000 megacycle) signals; increasing the reliability of components used in electronic equipment; improvement in the reliability and performance of electron tubes; and increasing the capacity, performance, and reliability of semiconductor devices.

In the generation and transmission of ultrahigh-frequency signals, television stations were placed in operation in the bands allocated to this service. Klystron tubes developing relatively high powers were used for final amplifier stages of both video and audio signals. Two forms of klystron tubes have been developed to date for this service, one design having integral cavities and one separate cavities.

An 1,840-mile microwave line radio-relay is being used to control the flow of 500-million cubic feet of natural gas daily in a 30-inch pipe line extending from the Texas and Louisiana fields northward to the eastern seaboard as far as New Jersey.

Increased reliability of vacuum tubes has aided the rapid advance and utilization of computers of both the digital and analogue type in industry. In particular, analogue computers, of greater flexibility and lower cost, have been made available for commercial usage. With these computing facilities a new professional field of "Operation Research," which deals with methods and systems as a scientific aid to management problems, is beginning.

In the semiconductor devices field, higher current and higher voltage units are being made available to industry, and the trend to hermetic sealing of the device itself has improved the stability of its characteristics.

Temperature-controlled ignitron tubes were made available to industry for resistance-welding equipment. Such tubes offer greater assurance of protection against overtemperature as well as the possibility of large savings in the amount of water required for cooling.

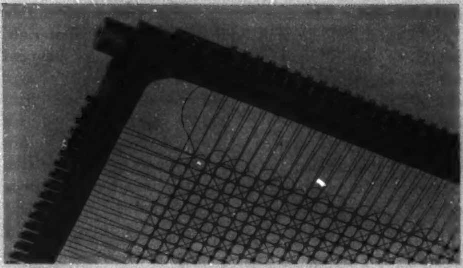
The year marked the culmination of intense effort by the armed services to provide an adequate supply of hydrogen thyratron tubes for pulse-modulation (radar) service.

Color television came a step nearer to reality with the development of practicable color-television tubes and the solution of many of the problems necessary to provide a system "compatible" with monochrome transmission.

"Project Tinkertoy" was developed by the Bureau of Standards for the Navy to demonstrate the possibility of an automatic factory for the manufacture and assembly of electronics equipment.

ELECTRONIC POWER CONVERTERS

Mercury-arc power rectifiers have found wide acceptance by the steel industry for continuous main roll drives. Several new drives were put into operation in 1953. There are now installed or on order in the United States more than 130,000 kw of rectifier capacity for hot strip, tube, and skelp mills. Outstanding characteristics are high momentary overload capacity and capability for close voltage regulation.



Toroidal ferramic cores (outside diameter, 0.090 inch; inside diameter, 0.060 inch; and thickness, 0.030 inch) with a rectangular hysteresis loop make up this random-access parallel memory developed at MIT. A peak current of about 1 ampere at 0.1 volt is used to switch a core, the energy required being of the order of an erg; the read-write time of the memory in the Whirlwind I computer, including selection and setup, is 9 microseconds, with the actual switching taking place in 1 microsecond. At the intersections of a grid of 32×32 co-ordinate-selection wires are placed 1,024 cores, so that any core is affected only by the coincident application of a 0.5-ampere pulse to each of the two lines passing through it; reading uses a sensing winding threaded diagonally through all the cores of a plane. Seventeen of these planes are used for parallel storage in Whirlwind I

Electronic drives for adjustable-speed motors, and having ratings of a few hundred kilowatts, have continued in popularity. Designs of these units feature smaller excitation circuit components and the use of static amplifiers for motor field supply.

Interest in mechanical rectifiers has continued with installed capacity reaching 220,000 amperes. Significant improvements have been made in operating mechanisms to facilitate timing adjustment and increase contact life, and also in voltage control means. A new 12,000-ampere draw-out mechanism has been developed, as shown in the left-hand side of the illustration on page 26.

Progress has been made in the larger sizes of ignitrons, where the trend is toward greater use of sealed, reconditionable units. A new model, shown in the illustration, featuring reduced weight and dimensions has been introduced. Design of the original large pumpless units has been refined to increase operating life. Proved life of units installed in 1948 now exceeds 5 years.

The largest electrochemical cell line to date, totaling 125,000 amperes at 800 volts, was put into operation in 1953. The problem of calculating fault current duty in such installations has been facilitated by the use of digital and analogue computers.

Improvements aimed at increased reliability have appeared in electronic exciters for large a-c generators.

Hot-cathode rectifiers continue to find new applications in the power field. An interesting example is a closely regulated power supply for a computing machine. Inverters for supplying 400-cycle power have been developed also.

INSTRUMENTS AND MEASUREMENTS

Meters. A wide diversity of studies and developments in measurement techniques and products were made during 1953. Improvements in damping magnet materials, bearings, and thermal capacity of the current element have made possible watt-hour meters with very large extension in range of meter performance. The two principal nominal ratings of 15 and 50 amperes provide for maximum current capacity of 100 and 200 amperes within the usual requirements of accuracy and temperature rise. A combination watt-hour–thermal demand meter (illustrated) with extended range is also available.

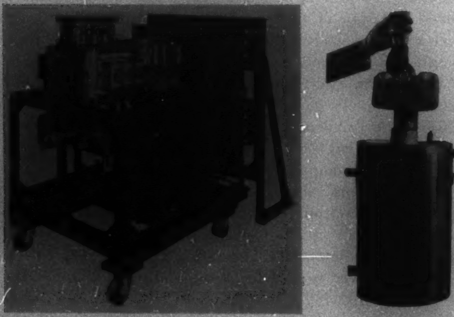
Electronic Instruments. In this field there has been a general up-grading in the quality of instruments and devices to make the instruments cover the full breadth of the work to be accomplished. They are designed for production. For example, oscilloscopes are directly calibrated since the linearity has been improved and long-time stability has been achieved. This has been accomplished by refined design and tight control of gun structure.

Telemetering. Telemetering in the field of guided missiles and aircraft has increased in importance due to the value of increasingly complex measurement systems. Defense developments requiring guided missiles necessitated new telemetering techniques. Of major importance is a new FM/FM system which transmits up to 15 variables to ground during flight with a stable linear oscillator and less susceptibility to environmental changes. It requires less space and power requirements than previous systems.

Central station generation now can be allocated in a more efficient manner by use of automatic allocation equipment which operates in connection with load-frequency control devices. It can adjust better to fast load changes and in some versions can do so with conservation of information channel space due in part to development and application of continuous and faster responding telemetering.

Recording. A portable rugged standard of current, known as a Magnettor current standard, which depends upon automatic comparison of a current-derived magnetic field with that of a stable permanent magnet, has been built. It is used as a reference in measurement circuitry for calibrating. When held at constant temperature, the device held an accuracy of 0.01 per cent for several days when compared with standard cells. An accuracy of 0.05 per cent is maintained over a 30-degree-centigrade change in temperature.

A combination watt-hour–thermal demand meter with extended range



On the left is shown a 12,000-ampere drawout-type mechanical rectifier and on the right is a 12-inch sealed ignitron rated at 667 amperes at 250 volts direct current

The difficult measuring problem of recording the resistance of the standard platinum resistance thermometer has been achieved successfully by means of a precision recorder. Features are included in the recorder which permit its unattended operation with a precision approaching 0.001 ohm which corresponds approximately to 0.01 degree centigrade for a 25-ohm platinum thermometer.

Navigation. Several radio systems have been developed for locating a ship's position on the earth's surface and for tracking it. The measurement of phase, as is done in the Raydist systems, offers accuracies which are of a high degree for medium ranges and accuracy with propagation beyond the line of sight comparing very favorably with the best results of pulse systems. Refinements continue to be developed rapidly.

Miscellaneous. A measurement system called an evenness integrator has been developed to determine the mean and the standard deviations of an important parameter, such as a dimension of a product. Materials can be tested while moving and the system responds continuously to the varying dimensions throughout the length of the sample, a matter of statistical importance.

In the aircraft instrument field, a mass flowmeter system for accurately measuring the fuel consumption rate of jet aircraft engines will simplify the work of pilot or flight engineer. Since the flowmeter measures true mass rate of fuel consumption, fuel density errors due to type and temperature of the fuel are automatically eliminated. A constant-speed impeller imparts to the flowing fuel rotational energy that is absorbed by a spring-restrained turbine whose angular position is a direct measure of mass-rate of flow, and is telemetered to a panel-mounted indicator.

MAGNETIC AMPLIFIERS

ENGINEERING advancements in the field of magnetic amplifiers during the year 1953 related largely to their application to so-called "power" applications. New techniques developed in the preceding several years and applied to smaller, lower power, instrument-type systems now are reaching to the power field.

This year, the development of a magnetic amplifier-excitation system for large electrical utility synchronous machines was culminated by an installation on a 50,000-kva turbine generator of the West Penn Power System. Static, tubeless components are employed throughout the new excitation system to provide reference, regulation, and minimum excitation limiting functions.

Magnetic amplifiers have been applied also to the control of individual stands of a 66-inch-wide 3,100-feet-per-minute tandem cold reduction steel mill. The magnetic amplifiers control generators totaling 14,200 kw, which supply four stand motors and a reel motor, totaling 17,700 horsepower. A 400-cycle supply frequency is employed to minimize the response time of the mill control and regulating systems.

A complete line of all-magnetic amplifier adjustable-speed drives between 1/4 and 5 horsepower became commercially available this year. This new equipment combines magnetic amplifier units with selenium rectifiers for the control of d-c motors as shown in the accompanying illustration. It is indicative of the progress which has been made in the development of standard line motor control apparatus containing magnetic amplifiers.

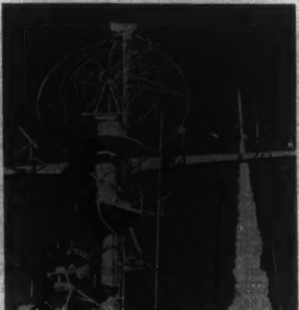
Magnetic amplifier units combined with selenium rectifiers for the control of d-c motors

Several improved, magnetic-type static voltage and current reference units have been developed during the past year. One reference unit differs largely from the others in that it contains no permanent magnet elements. This nonpermanent-magnet-type unit provides a ±0.5-per-cent current or voltage reference output from −55 degrees centigrade to +65 degrees centigrade and for input ranges of 90 to 130 volts and 360 to 440 cycles.

The development and improvement of magnetic amplifiers for servomotor control, thermocouple and other temperature detection and control, and other instrumentation applications has also shown great progress during the past year.

METALLIC RECTIFIERS

The trend towards greater power concentrations in electrochemical plants is continuing. This has encouraged the development of larger rated metallic rectifiers to meet these requirements. One of the latest developments by the General Electric Company is a large single cubicle germanium rectifier rated 120 kw capable of delivering 65 direct volts at 2,000 amperes continuously with an over-all conversion efficiency at full load of 94 per cent. These cubicles are approximately 4 by 4 by 5 feet in size and use a liquid-immersed–water-cooled germanium assembly as a rectifying device. By connecting several cubicles in series and multiple it is possible to increase the over-all rating of an installation to meet almost any possible requirements of the industry.



An upper-air research missile, the "Aerobee," which utilizes much telemetering to send its information back to a ground station. Receiving telemetering antenna and radar equipment in the foreground

Germanium, unlike other metallic rectifiers, shows no aging for periods now extending over 2 years. The year 1954 probably will see many of these new germanium-type metallic rectifiers in operation throughout the United States.

There has been developed at the Bell Telephone Laboratories a new type of power converter for low-voltage applications in the range of 1 to 40 kw. It is designed primarily for floating storage batteries in the 24/48-volt range.

The rectifying elements of a 10-kw design are six diffused junction germanium power diodes connected in a 3-phase bridge circuit and cooled with forced air. A regulating circuit has been developed that provides a constant output voltage ±1 per cent with line and load variations and over an ambient temperature range of 0 to 40 degrees centigrade. At full load, the rectifier automatically converts to constant current regulation to prevent overheating of the rectifier components. These characteristics are obtained entirely with semiconductor and magnetic devices.

For voltage regulation, the output voltage is compared to a reference voltage in a transistor error detector circuit. The reference voltage is obtained from a "voltage-limiting" silicon diode. The error detector drives a 2-stage transistor current amplifier. Sufficient power is derived to control a magnetic amplifier which consists of a saturable reactor in series with each power diode. "Square hysteresis loop" materials and gapless construction are used for the cores of the reactors. This together with the low reverse leakage of the power diodes provides a high power gain and fast speed of response.

Production of Unipolar Air With Radium Isotopes

T. L. MARTIN, JR.
ASSOCIATE MEMBER AIEE

A general survey of recent development work on the sources of unipolar air using alpha-emitting radioactive materials is presented. A new device, which operates at relatively high air speeds of about 450 feet per minute, provides an air output containing only positive or only negative ions. The method of controlling the density of this unipolar output also is discussed.

UNIPOLAR AIR is air that contains ions of only a single polarity. There are many industrial applications in which it is necessary or desirable to have facilities for discharging electrified particles that adhere to materials or machines. It also has been suggested that atmospheric ionization can be used to cleanse rooms of contamination such as smoke, dust, certain pollens, and some viruses. Such an action in conjunction with air-conditioning systems would prove extremely beneficial to sufferers from various allergies. With such an apparently diversified group of applications awaiting the availability of appropriate sources of unipolar air, it is not surprising that the development program has received considerable impetus.

Unipolar air may be produced in a number of different ways, but for reasons discussed elsewhere,* thermionic and alpha particle radiation methods appear most suitable. It has been shown that thermionic methods lack the necessary degree of control, uniformity of output, and predictability desirable in ion sources.[1] Thus, it is concluded that ion production through alpha particle radiation offers the greatest immediate area for potential development.

CHOOSING THE RADIOACTIVE EMITTER

IN SELECTING the radioactive material for use in an ion generator, there are two main factors of importance to be considered:

1. The half-life of the emitter should be quite long. From the commercial viewpoint, a desirable half-life would fall in the 3- to 5-year region since this assures a reasonable shelf life for the manufactured ion sources. Moreover, this would be long enough to maintain a relatively constant ion output over the duration of most biological tests and would not require frequent replacement of units in commercial applications.
2. The emission of alpha particles should not be accompanied by strong beta or gamma radiation, nor should disintegration produce an isotope that subsequently will produce strong beta or gamma radiation.

With the foregoing factors in mind and with all cost considerations temporarily set aside, it was concluded that there are no satisfactory isotopes in the thorium or actinium series.

There are numerous alpha-emitting isotopes of radium that disintegrate with long half-life periods. However, radon is an ultimate product of the disintegrations of the heavier isotopes. Since it is a gas and radioactive, it is very dangerous to work with and should be avoided. Thus, all isotopes above radon in the series are ruled out.

Radium G is the nonradioactive end product of the radium series. Radium F, otherwise known as polonium, emits alpha particles only, reducing to Radium G with a half-life of about 140 days. It would be an ideal alpha particle source if it had a longer half-life. It is relatively inexpensive in comparison to other isotopes.

Radium D disintegrates to Radium E and thence to polonium. In doing so, it radiates both beta and gamma rays of appreciable, but relatively low, energy. The transformation occurs with about a 22.2-year half-life. An equilibrium mixture of Radium D and polonium is thereby an effective alpha particle source having a half-life of about 22 years.

The main disadvantage involved in the use of Radium D is the presence of beta and gamma radiations. Fortunately, the energy levels are comparatively low. Careful attention to shielding is required, but this is primarily a detail and not at all impossible to handle. Radium D is considerably more expensive than polonium, but in view of the 22-year half-life, it well could prove to be more economical.

One more factor should be noted in connection with the use of polonium and Radium D. It has been shown in the case of some types of polonium foils that free polonium atoms are produced when alpha particles are emitted. In such cases, free polonium would be circulated into the air and would constitute a serious physiological problem. It appears that this problem has been overstated in some instances and the advanced methods of foil preparation described in the following section have ended the problem.

PREPARATION OF THE ALPHA EMITTER

THE ALPHA EMITTER used in all of the devices described in this article was polonium foil. The method of pre-

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* Control of Air Ion Density in Homes," H. H. Skilling, J. C. Beckett; a paper presented at the AIEE Winter General Meeting, New York, N. Y., January 19–23, 1953.

Full text of paper 53-351, "Production of Unipolar Air With Radium Isotopes," recommended by the AIEE Committee on Basic Sciences and approved by the AIEE Committee on Technical Operations for presentation at the Pacific General Meeting, Vancouver, British Columbia, Canada, September 1–4, 1953. Scheduled for publication in AIEE *Transactions*, volume 72, 1953.

T. L. Martin, Jr., is with the University of Arizona, Tucson, Ariz.

paring this foil is summarized briefly here. The information presented is a permitted quotation from a personal communication from C. W. Wallhausen, vice-president, United States Radium Corporation, the supplier of the foils.

"The polonium is precipitated as a hydroxide mixed with silver powder. The intimately mixed powders then are introduced into a die and formed into a solid compact by heat and pressure. The radioactive component is then rolled to predetermined dimensions and is then ready for incorporation into a foil sandwich. The sandwich is composed of a base, consisting of a 1/8-inch silver block. A thin layer of inactive gold is laid over this base. A section cut from the radioactive compact is laid over this and another sheet of inactive gold is then placed over this. The entire unit is then compressed by heat and pressure into a solid fused block. The block is then rolled into ribbon form to an over-all thickness of 0.005 to 0.006 inch. In this form, most of the foil thickness is due to the silver backing. Accordingly, alpha particles can be emitted only from the side without the silver backing.

To add a harder and abrasion resistant surface, the rolled foil is given a final coating of about 0.4-micron thickness of rhodium or palladium. This improved foil is definitely *not* causing any of the old migration contamination troubles that are associated with polonium sources."

IMPORTANT ASPECTS OF AIR IONIZATION WITH ALPHA PARTICLES

As THE MAIN CONSTITUENTS of air, oxygen and nitrogen, are diatomic, the discussion is concerned mainly with molecular rather than atomic effects. When alpha particles are emitted into this mixture, they collide with molecules of both gases producing free electrons and positive molecular ions of oxygen and nitrogen.

Oxygen readily forms negative molecular ions. Thus, except for a small number of electrons lost through recombination, the free electrons become attached to oxygen molecules. None of the electrons becomes attached to nitrogen molecules because it has been shown (reference 2, page 289) that molecular nitrogen does not form negative ions. Thus, the ultimate result of the passage of alpha particles through air is the production of negative molecular ions of oxygen and positive molecular ions of nitrogen and oxygen with the former predominating.

The mobility of an ion is its velocity in a unit electric field. If an absolutely pure gas could be obtained, at a constant pressure there would be a unique value for the mobility of an ion in that gas, starting about 1 microsecond after ion formation (reference 2, page 33). However, such a gas does not exist and ion mobilities are found to vary over a wide range as a result of gas contamination and age of the ion.

As a result of the large variations in measured ion mobilities, there is no one value applicable for a given ion in a given gas. Thus, designers of ionizers should be wary of basing their design upon a special value for ion mobility taken from tables.

LOSSES

THE NUMBER OF ions that can be produced in air by an alpha emitter of known activity is easily computed. The number of ions obtained in the output from the ion tube can be determined experimentally. The ratio of the actual ion output to the theoretical maximum ion formation rate can be used as an index of the efficiency of the tube in utilizing the available ionizing capabilities of the alpha emitter.

This efficiency always will be less than 100 per cent. The reasons for this might be listed as follows:

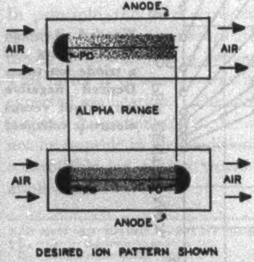
1. Recombination losses.
2. Alpha emission losses in the emitter.
3. Alpha absorption in the collimator.
4. Ionization losses in the separation process.

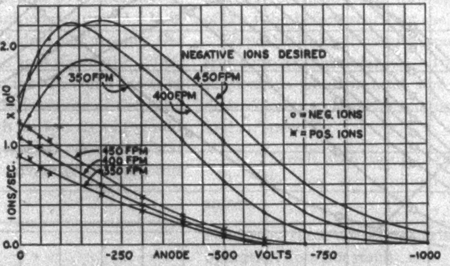
Loeb (reference 2, page 37) lists four types of ion recombination of potential importance here:

1. Preferential recombination.
2. Initial recombination.
3. Columnar recombination.
4. Volume recombination.

Regardless of the type of recombination, the rate of recombination can be computed from the general equation

$$\frac{dN(+)}{dt} = \frac{dN(-)}{dt} = -\alpha N(+)N(-)$$





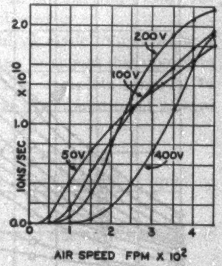
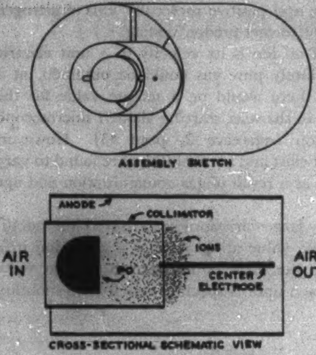


Figure 1 (left). 2-Electrode ion tubes. **Figure 2 (center).** Characteristics of 2-electrode ion tubes: Ion output versus electrode voltage. **Figure 3 (right).** Characteristics of a 3-electrode ion tube: Desired output versus air speed



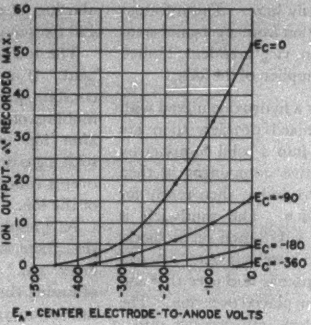


Figure 4 (left). Triode ion tube. Figure 6 (right). Average characteristics of triode ion tube: Undesired positive ion output versus electrode voltages†

where

α = recombination coefficient
$N(+)$ = density of positive ions
$N(-)$ = density of negative ions

However, the calculation is possible only if the recombination coefficient is known and, according to Loeb (reference 2, page 147), "tables of values for α are more or less meaningless." Thus, recombination losses do occur and the extent probably is appreciable, but it cannot be calculated with any degree of certainty.

Alpha losses in the emitter are largely caused by the construction of the polonium foil. From the foil preparation process described earlier it is clear that, on the average, only half of the disintegrations will eject alpha particles into the air because half of them will be absorbed in the silver backing. Alpha radiation parallel or close to parallel to the foil surface is weak because of the retardation of the rhodium or palladium coating. Also, because of this coating, all alpha particles will experience some retardation and loss of ionizing capability. Consequently, the effective alpha radiation from the foil is considerably less than the theoretical maximum of the polonium imbedded in the foil.

The alpha particles are emitted from the forward surface of the polonium foil in a fan-shaped pattern.[3] This pattern is undesirable in some instances and collimating devices are used to confine the alpha radiation to a more beamlike pattern. This is accomplished by absorbing that radiation occurring at oblique angles from the foil surface. This absorption further reduces the effective activity of the emitter in producing ions.

To produce unipolar air from an original bipolar sample, some sort of ion separation mechanism must be used. It is inevitable that some of the desired ions will be lost in the process.

Ideally, these four losses could be separated and individually determined so that efficiency improvements could be made on an exact basis. Unfortunately, the author has not been able to do this and is not sure that it can be done.

SINGLE ELECTRODE ION TUBE

ONE OF THE first radioactive ion tubes produced in any volume to serve as a source of unipolar air was developed by J. C. Beckett. The tube has been described

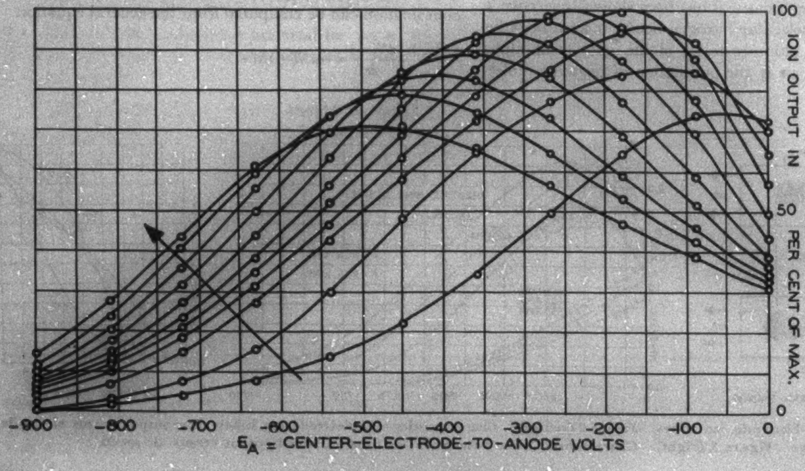


Figure 5. Average characteristics of a triode ion tube: Desired negative ion output versus electrode voltages†

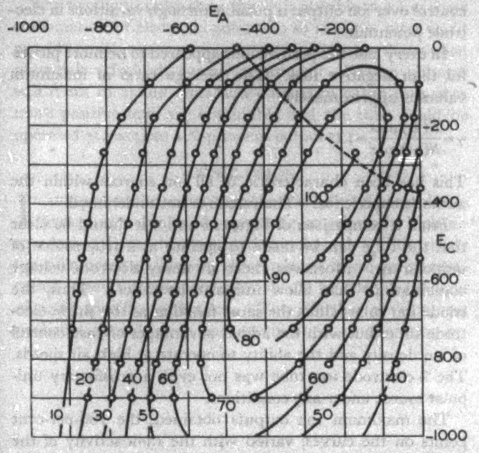


Figure 7. Average control characteristics of a triode ion tube: Negative ions desired.†‡ Dashed line is contour for zero positive ion output

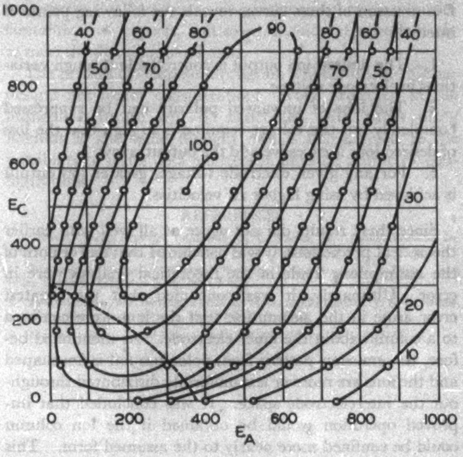


Figure 8. Average control characteristics of a triode ion tube: Positive ions desired.†‡ Dashed line is contour for zero negative ion output

in detail.§ It has proved to be a very useful tool in preliminary experimentation and may represent the best solution to certain commercial requirements.

The tube consists of a single tubular electrode with a strip of polonium foil mounted on one side of this electrode. A rectified alternating voltage is applied between this electrode and ground. The dimensions of the tube, the location of the polonium, and the applied potential are all critically related to one another. The electrostatic flux lines go between the tubular electrode and nearby grounded objects such as the floor, walls, ceiling of a room, or possibly even nearby people. The flux distribution in the tube opening is altered only slightly when the locations of these grounded objects are changed.

The operation of the tube is rather simply explained in principle. Alpha particles emitted by the polonium ionize the air inside the tube. If negative ions are desired in the output, the tubular electrode is made negative with respect to ground. The field configuration is such that negative ions drift out of the tube into the air while the positive ions are attracted to the electrode and are discharged. In principle, the tube provides a unipolar output.[4] It is a simple tube, easy to fabricate, and does not require the use of a blower fan to remove the ions from the tube. This factor is of considerable importance in some areas of expected application. The main disadvantage of the tube is that it is not adapted to use at high air speeds and would not be suitable in air-conditioning systems. A higher and controllable ion output would be advantageous for this application.

2-ELECTRODE ION TUBES

Two-electrode ion tubes were the first step taken in an effort to develop an ion source capable of operating at high air speeds. A cross-sectional schematic view of two early experimental models is shown in Figure 1. There are two coaxial electrodes with the alpha-emitting polonium facing axially down the tube. The ionization produced by the alpha particles would be confined, desirably, to a column about the inner electrode as shown in this figure.

In operation, an electric field is established between the two electrodes and a relatively strong blast of air (450 feet per minute) is directed axially down the tube. The electric field strength varies inversely with the distance from the center electrode. Thus, the ions nearest this electrode are subjected to the strongest electrostatic forces. The ions of unwanted polarity are attracted toward the inner electrode into an ever-increasing field intensity and are rapidly removed from the interelectrode space. The ions of desired polarity are forced toward the outer electrode into a field that becomes progressively weaker. These ions are thereby forced into the moving air stream and blown out of the tube before reaching the electrode.

Hypothetically, this tube could be made to operate as a true source of unipolar air. It can be shown that complete suppression of unwanted ions and complete removal of desired ions can be achieved for any combination of voltage and air speed if:

1. There is no fringing of the electric field.
2. The ions are confined to a cylindrical column as shown.

Neither of these conditions exists and this optimum kind of operation does not result.

Several of these tubes were constructed and tested. Some representative results are given in Figures 2 and 3.

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† Air speed approximately 450 feet per minute
‡ E_A = Center electrode-to-anode volts
E_C = Collimator-to-anode volts

§ "Control of Air Ion Density in Homes," H. H. Skilling, J. C. Beckett; a paper presented at the AIEE Winter General Meeting, New York, N. Y., January 19–23, 1953.

Examination of these curves reveals the following points of interest:

1. The desired ion output is controllable through variations in electrode voltage.
2. The ions of unwanted polarity can be suppressed completely but the voltage required is so high that the loss of desired ions is excessive and the output is low.
3. For any given electrode voltage, greater ion output is achieved by using higher air velocities.

Since these results did not agree at all well with earlier theoretical predictions, it was concluded that one or both of the assumptions made in the theoretical analysis were in error. Ultimately, it was concluded that the greatest error arose in the assumption that the ions were confined to a column about the inner electrode. As mentioned before, the emission pattern from polonium foil is fan shaped and the ions are more or less uniformly distributed throughout the interelectrode space. It was concluded that improved operation would be obtained if the ion column could be confined more nearly to the assumed form. This required the introduction of a collimating device and led to the triode ion tube.

TRIODE ION TUBES

Several different methods of collimating the alpha particle radiation are being studied. However, only one type is covered here. The essential geometric configuration of the tube is shown in Figure 4. The collimator is made of aluminum and serves as the third electrode of the tube.

In taking data, the anode is used as the reference, or grounded, electrode. The tube voltages then are specified as follows:

E_A = center electrode-to-anode volts
E_C = collimator-to-anode volts

All tests reported here were conducted with an average indicated air speed of 450 feet per minute. Preliminary tests with other air speeds indicate higher ion outputs can be obtained at higher air speeds. This suggests that the separation losses are still appreciable.

The operating characteristics of the tube at an air speed of 450 feet per minute are shown in Figures 5 and 6. Although these only show the case where negative ions are desired, essentially the same results are obtained when positive ions are desired. These are average characteristics in the sense that they are the average of several sets of data taken under varying degrees of air temperature and pollution. These two factors have some effect upon the results, but there were no variations in excess of 5 per cent under the conditions tested.

The method of data presentation requires some explanation. Each point is expressed as a percentage of the maximum obtainable desired ion output under all electrode voltage possibilities. It was necessary to use some sort of normalizing procedure like this since the continually diminishing activity of the polonium made the use of absolute values impractical.

From these curves it is apparent that a wide latitude of control over ion output is possible through variations in electrode potentials.

In every case the positive ions appeared to be more plentiful than negative ions. The average ratio of maximum values is approximately

$$\gamma = \frac{N(+)\,\text{max}}{N(-)\,\text{max}} = 1.15$$

This has been characteristic of all ion sources within the author's experience. The reason is not understood.

From a comparison of Figures 5 and 6 it should be clear that the tube can be made to operate as a true source of unipolar air. Moreover, there are many electrode voltage combinations that allow unipolar operation. Thus, the triode ion tube fulfills the same function as the single electrode tube, but with the added advantages of easy control of ion density and the ability to operate at high air speeds. The 2-electrode ion tube was not even a satisfactory unipolar source under any conditions.

The maximum ion outputs obtained, the 100-per-cent points on the curves, varied with the radioactivity of the polonium. Although facilities were not available to measure the activity of the polonium, it appears that the maximum ion output with about 200 microcuries of polonium is about 1.2×10^{10} ions per second. This amount of radioactivity will produce a theoretical maximum of about 118×10^{10} ion pairs per second. Thus, the output is only about 1 per cent of the theoretical maximum. This is not a bad figure when corrected for alpha losses in the emitter. However, it undoubtedly could be increased somewhat through improved tube design and the use of higher air speeds.

CONTROLLING THE ION OUTPUT

The method of controlling the density of ions in the unipolar output from the triode ion tube can be deduced from the average control characteristics given in Figures 7 and 8.

In both of these figures a potential plane has been constructed with the collimator voltage, E_C, plotted vertically and the center electrode voltage, E_A, plotted horizontally. Contours of constant ion output are drawn on that plane. That is, the 70-per-cent contour shows all of the possible electrode voltage combinations that will produce 70 per cent of the maximum obtainable ion output. Similar contours are drawn for all percentages from 10 to 100 per cent in 10 per cent increments.

The contour for zero undesired ion output also is shown on each of these figures. If the operating point of the tube falls within this contour, the tube no longer operates as a source of unipolar air. It is particularly interesting to note that a more precise adjustment of electrode voltages is required for optimum operation of the tube as a source of negative air than when positive air is desired.

These two figures show how the ion output is best controlled by variations in electrode potentials. Clearly, the desired ion output should be controlled by causing the operating point to shift approximately parallel to the 0-per-cent contour of undesired ions. This will maintain a unipolar output under all conditions.

The two figures also show that it is possible to select some combination of electrode potentials so that the tube could provide positive or negative air just by reversing the applied potentials. Indeed, careful adjustment of these voltages will result in almost equal ion outputs in either case since more positive ions are obtainable and the tube could be operated at less than 100-per-cent output.

CONCLUSION

IT APPEARS to the writer that the feasibility of controllable sources of unipolar air operating at relatively high air speeds has been demonstrated conclusively. The triode ion tube needs engineering development to reduce its separation losses, but this preferably should be done in the light of some specific application. Thus, further development probably should await the specification of operating requirements by biologists, air-conditioning engineers, decontamination experts, and so on, for no one tube is likely to meet the demands of all users.

The present development program will continue. Other designs are under consideration. Work projected in the immediate future will be concerned with tubes using Radium D and some thought also is being given to the possibility of using beta emitters in unusual geometric configurations.

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Motor Insulation Life as Measured by Accelerated Tests and Dielectric Fatigue

C. J. HERMAN
MEMBER AIEE

The best life test for fractional-horsepower motors should apply simultaneously or cyclically the major deteriorating factors to the insulation system. These are considered to be heat, voltage, vibration, and humidity. The closer the life-test cycle can match or accelerate possible service conditions, the greater value it will have.

THE ART OF insulating small motors is in the midst of revolutionary changes that call for quick answers. The chemists and chemical engineers have brought forth amazing new synthetic insulation materials: nylon, polythene, Kel-F, Teflon, phenolic-Formvar, "Mylar" polyester film, silicones in many forms, solventless varnishes, Micamat, new magnet-wire enamels. These accomplishments need to be matched by fast-changing, accurate methods of evaluation by the electrical industry.

Measuring the performance of a new insulating material is a difficult task. There are no industry standards for performance, and no generally accepted specifications for kinds of tests and the test conditions that must be met. For these reasons the "Proposed AIEE Test Code for Trial Use for Evaluation of Systems of Insulating Materials for Random-Wound Electrical Machinery" represents a big step forward in the electrical industry. The code proposes that insulations be evaluated upon the sound basis of performance, rather than upon the increasingly unsatisfactory basis of chemical composition. It is hoped that the code will be thoroughly tried, be amended as experience dictates, and be adopted by industry in the reasonably near future.

Over the years designers of all kinds of electric equipment have learned to insulate their systems reliably by experience, and by realistic tests specifically fitted to their particular lines of apparatus. Superficially, there may seem to be no common basis for the many evaluation techniques. Actually three steps for the evaluation of insulation are used almost universally. In a nonelectrical but related engineering field, these steps have been well-stated by A. C. Elm:[1]

1. The formulation of a theory of what is needed.
2. The actual development of an instrument or technique, or both.
3. The extensive use of this instrument or procedure to demonstate its parellelity with actual service experience.

Everyone evaluating insulation systems by accelerated life testing soon recognizes the extreme importance of establishing the closest possible approach to realistic condi-

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Complete text of paper 53-301, "Motor Insulation Life as Measured by Accelerated Tests and Dielectric Fatigue," recommended by the AIEE Committee on Rotating Machinery and approved by the AIEE Technical Operations Committee for presentation at the AIEE Summer General Meeting, Atlantic City, N. J., June 15–19, 1953. Scheduled for publication in AIEE *Transactions*, volume 72, 1953.

C. J. Herman is with the General Electric Company, Fort Wayne, Ind.

The author acknowledges the excellent assistance of R. E. Seely in perfecting an automatic temperature-control circuit for motor life tests, and of R. K. Drake for the establishment of consistent corona-measurement techniques.

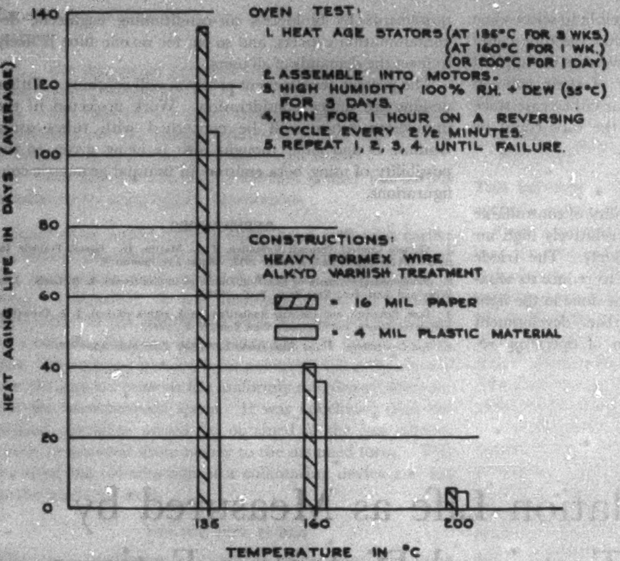

Figure 1. Accelerated life tests on complete a-c motors

tions. For best results, there must be simultaneous or suitably cyclic applications of the major deteriorating factors wherever possible.

Combinations of deteriorating factors often reduce insulation life to a fraction of that obtained by application *singly* of the deteriorating conditions. In accelerated life tests on small motors, heat-aging plus humidity have given an average life equalling only 60 per cent of that obtained by heat-aging alone. This is shown by K. N. Mathes.[2]

For conventional fractional-horsepower motors, it is believed that the major deteriorating factors are: heat, voltage stress, vibration, and humidity. This belief has been accepted for about 14 years by those responsible for the design of General Electric fractional-horsepower motors. It has been substantiated by tests to destruction on several hundred motors during that time. These results have been reported by K. N. Mathes,[2] and J. A. Scott and B. H. Thompson.[3]

These excellent life-test techniques called "oven method" and described in Figure 1, have been incorporated in the previously mentioned proposed AIEE Test Code. It is believed that this test on complete motors adequately combines heat-aging, humidity, and vibration. It may be somewhat inadequate as regards the effects of voltage stress, because power is applied to the windings only 0.2 to 4.0 per cent of the actual heat-aging time. Principal features of this oven method test technique are: 1. many motors can be conveniently tested simultaneously; 2. costs are relatively low; 3. temperatures can be very accurately controlled in ovens. Results of some recent Oven Tests to determine the thickness of plastic film to use in fractional-horsepower motors are shown in Figure 1.

During the past year, a real advance in insulation accelerated life tests on small motors has been made, based on the closest practical approach to realistic operating conditions. This technique, called the "self-heating method" and described in Table I, is also incorporated in the proposed AIEE Test Code. The test is made on a-c motors perfectly standard in every respect, except that the air gap is increased so that the motor heats itself to desired winding temperatures at no load. Temperatures may be controlled automatically by a thermostat, mounted on the motor case. This is connected to short-circuit a resistor in series with the power supply whenever motor temperature drops, slightly increasing the voltage on the motor windings. The thermostat opens when the temperature tends to be too high thereby slightly reducing the line voltage on the motor. Figure 5 shows a life-test motor complete with automatic temperature-control circuit. Figure 6 shows corona-detection equipment and a number of motors running on the heat-aging portion of the life tests. Figure 7 shows motors in cabinets during the humidity cycle.

Exact comparisons between the oven method and the self-heating method have not been made because of limited experience with the latter method. Table I shows the relative orders of life expected on these tests. The first fully comparative tests probably will be completed in August 1953.

The principal features of the self-heating method of insulation accelerated-life tests are: 1. Winding temperatures are easily and accurately controlled; 2. Approximately *normal* temperature gradients exist between magnet wire, ground insulation, and leads; 3. The usual dielectric stresses prevail because the windings operate on rated voltage during all heat aging. Dielectric fatigue is continuously adding its deteriorating effects; 4. Service vibration conditions are simulated by a large number of start-stop operations; 5. The hot motors cool down in high humidity to simulate the worst moisture conditions likely to be encountered in service. There is a reasonable heat-shock condition, although it might well be argued that the low temperature is not as low as it should be; 6. The test cycle is practical to get maximum results in a short time at moderate cost; 7. The electrical measurements give clues to the degree of degradation of the insulation system. Measurements of insulation resistance and corona starting voltage are taken between windings, and between windings and ground. The corona measurements have particular significance as an analysis of the data to be presented will show.

In these tests, corona starting voltage may be defined as the minimum voltage (between core and windings or between windings) which produces high-frequency components which can be detected and separated from the normal 60-cycle charging current, amplified, and indicated on meters or a cathode-ray oscilloscope. In these tests, corona is measured by the "resonant circuit method" by a circuit of known high sensitivity as shown in Figure 2. This method of corona detection is described by G.E. Quinn.[4]

Corona starting voltage appears to be the most sensitive, significant, nondestructive measurement used in this research. It is especially useful to indicate incipient failure, or to locate weak spots in the insulation system during the progress of life tests.

Life tests on fractional-horsepower motors at Fort Wayne indicate that corona starting voltage may decrease sharply and with some regularity of pattern during heat-aging and humidity degradation of the insulation. This phenomenon is markedly true of some organic insulation systems such as *A* in Figure 3. In other organic systems, such as *B* and *C*, there appear to be little change in corona starting voltage until very shortly before insulation-system failure. It is not known why some insulation systems degrade much more rapidly and more regularly than others in their ability to withstand overvoltage. However it seems reasonable to conclude that the best system to use, as regards life, is the one which maintains corona starting voltage well above the usual motor operating voltage during accelerated-life tests. In designing and testing insulation systems, it is extremely important to note that different kinds of insulation materials differ greatly in their "time" abilities to withstand overvoltage or corona conditions. This is shown particularly well by Carl Brodhun and J. R. Perkins.[5]

Many organic insulation systems must be corona-free at the usual operating voltages, if long life is to be assured. This is indicated by R. D. Jones and E. M. Stanbery,[6] and by J. H. Mason.[7] This same phenomenon is shown in Figure 4. In these tests, the initial corona starting voltage was measured on single-phase fractional-horsepower motor stators, using the resonant-circuit method shown in Figure 2. Then the windings were subjected to continuous 60-cycle overvoltages to ground at ordinary room temperatures and humidity. The points as plotted on the curve are the averages:

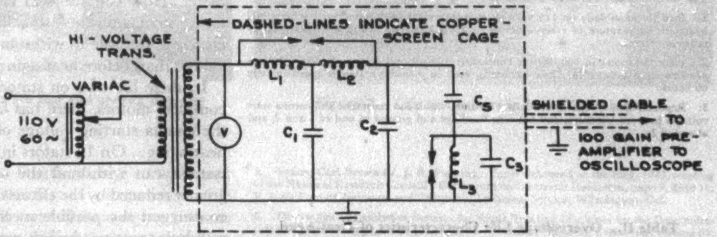

Figure 2. Corona test circuit used in Fort Wayne laboratory. Circuit components: C_s—core-to-winding or winding-to-winding capacitance; C_1 and C_2—0.002 microfarad, 20,000 volts effective; C_3—500 micromicrofarads mica; L_1 and L_2—85-millihenry chokes; L_3—0.225-millihenry low-capacity choke (transmitting type); V—electrostatic voltmeter 0–1,000–3,000–5,000 volts

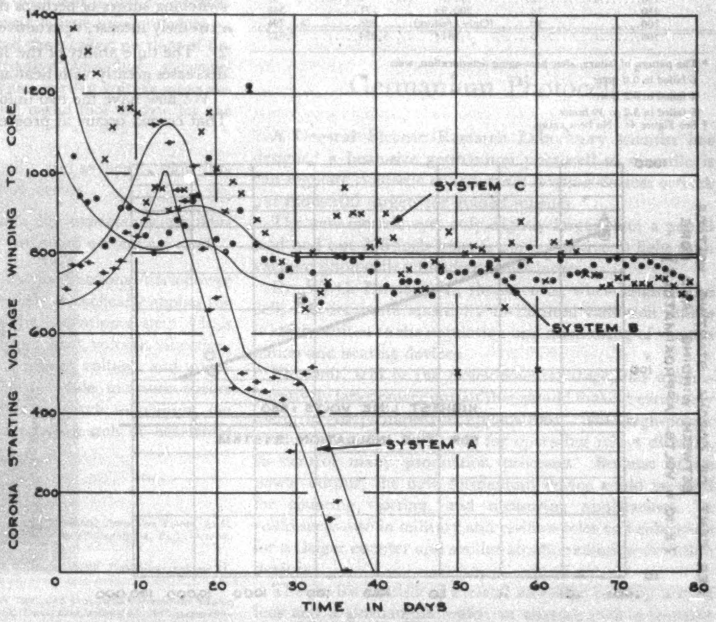

Figure 3. Corona starting voltage versus heat-aging life for three different Class A insulation systems (accelerated life testing per self-heating method—See Table I)

Table I. Oven Method Versus Self-Heating Method of Accelerated Life Tests on Fractional-Horsepower Motors

Quantity and Construction of Motors	Ground Insulation System	Average Heat-Aging Life in Days	Heat-Aging Life in Days	
			Minimum	Maximum
Oven Method				
12 Drip-proof	Acetate-coated-paper (16 mils thick)	42.1	32	60
Self-Heating Method				
5 Totally enclosed	Acetate-coated-paper (16 mils thick)	48.4	31.5	68.8
5 Totally enclosed	Plastic film (5 mils thick)	75.5	59.3	106.2

Test conditions for "self-heating method."

1. Run 15 hours daily on 115 volts on start-stop cycle (4 minutes on, 1 minute off) Maintain temperature of main windings at 160±5 degrees centigrade, measured by resistance rise.

2. Place hot motor in 100 degrees Fahrenheit/100-per-cent relative humidity for approximately 8 hours. (*a*) Over weekends, keep in humidity cabinets approximately 60 hours.

3. Repeat 1 and 2 until motor fails. Measure insulation resistance and corona start voltages between windings, and between windings and ground at end of 1 and 2, and at end of 2*a*.

Table II. Overvoltage Life Characteristics of Heat-Aged Conventional Paper Insulation System

Overvoltage Applied Between Windings and Core in Per Cent of Corona Starting Voltage	Quantity of A-C Stators	Overvoltage Life in Hours (After 37 to 56 Days Heat-Aging at 160 Degrees Centigrade)		
		Average	Minimum	Maximum
150	12	11.1*	0	39
150	14	200.9†	71	365
100	10	(Only 1 failure)	986	>3,796
100	6	5,781†	5,054	7,027

* The pattern of failure, after heat-aging deterioration, was:
6 failed in 0.0 hour
1 failed in 0.2 hour
5 failed in 3.2 to 39 hours
† See Figure 4: No heat aging.

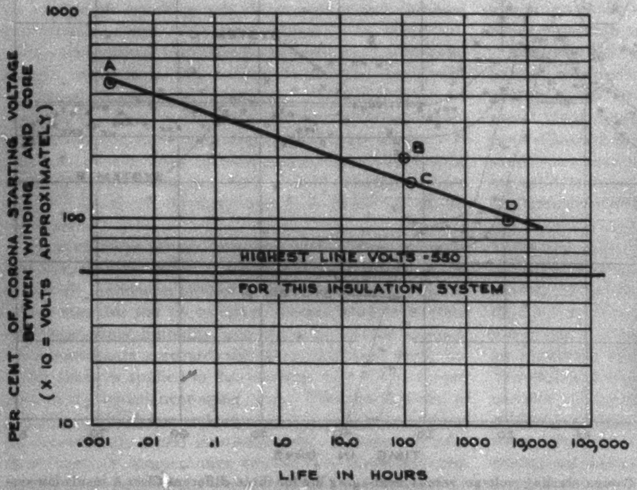

Figure 4. Overvoltage life characteristics of conventional paper insulation system

A of 60 stators, *B* of 14 stators, *C* of 14 stators, and *D* of 6 stators. The usual operating voltages of these stators are 115 or 230 volts, with a maximum of 550. This sort of overvoltage life testing has been done for several years in England on cables using different types of insulation. Life curves similar in shape to these were obtained by P. R. Howard.[8]

In accelerated life tests on motors, there have been many clues that heat-aging and voltage stress work together to deteriorate the insulation. In these tests attempt has been made to prove this phenomenon on cellulosic-insulated single-phase fractional-horsepower motor stators. At this time, the total data are very limited and only partially complete. However Table II clearly indicates that the cellulosic system, after these so-called 1/2- and 3/4-life heat-aging cycles, is less able to withstand overvoltage and corona discharge than before heat-aging as in Figure 4.

In these life tests on stators only, and in 39 life tests on complete motors, there has been convincing evidence that the corona starting voltage of some systems decreases with heat-aging. On 12 stators in Table II, the time which the systems can withstand the onslaught of corona has been greatly reduced by the effects of heat-aging. These phenomena suggest the possible mechanism of failure of the usual cellulosic systems during normal heat-aging and normal voltage stresses:

1. The voltage, at which destructive corona occurs, decreases as the insulation deteriorates due to heat-aging. Corona starting voltage may drop eventually to slightly over normal line voltage on the windings. Then during the usual switching surges of perhaps two to five times line voltages, extremely intense, destructive corona discharge occurs.

2. The time ability of the insulation to withstand corona decreases greatly with heat-aging deterioration.

We now have the two unfortunate compounding effects: That corona occurs at progressively lower voltage levels as

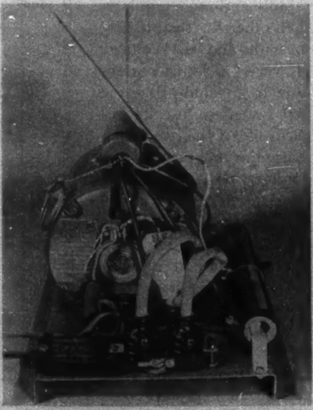

Figure 5. Life test motor with automatic temperature control

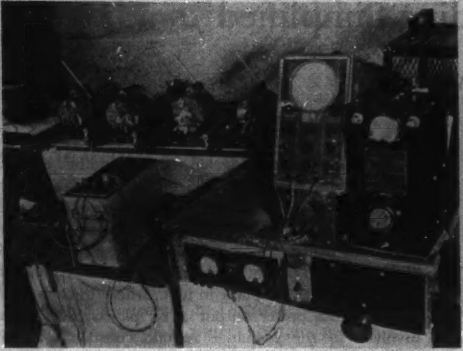

Figure 6. Self-heating motor life test and corona detector

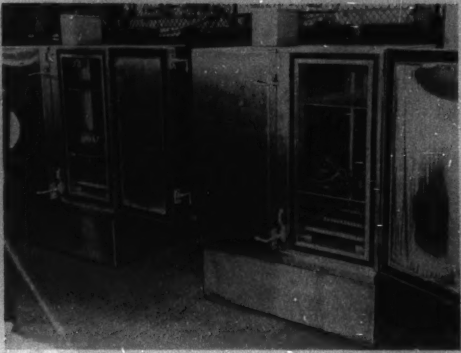

Figure 7. Life test motors in humidity cabinets

the systems heat-age, and the length of time to withstand destructive corona decreases sharply. It seems reasonable to assume that after years of normal heat-aging, intense highly destructive corona occurs during the usual switching surge voltages for the apparatus, and remaining life becomes very short. With this concept of the mechanism of failure, it becomes evident that systems should be designed to be corona-free after years of normal heat-aging at normal switching surge voltages for the particular applications.

The experience gained from these tests is that accelerated life tests on motors plus dielectric fatigue measurements on stators have conclusively located the weakest portions of the insulation systems. Nondestructive overvoltage measurements (otherwise known as corona starting voltage measurements) have provided the most useful tool to date for the following purposes:

1. To locate weak spots initially, and as they develop during life tests before actual failure occurs.

2. To give clues as to probable life expectancy, particularly where materials poor to withstand corona are used.

In conclusion, the best life test for fractional-horsepower motors is that which simultaneously or cyclically applies the major deteriorating factors to the insulation system. It is believed that the major factors are: heat, voltage, vibration, and humidity. In actual service, heat, voltage, and vibration usually occur simultaneously while moisture occurs cyclically. In the best possible approach to realism, the life-test cycle should be designed to match or accelerate these possible service conditions.

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Germanium Photocell

A General Electric Research Laboratory scientist has designed a bean-size germanium photocell so versatile it can regulate domestic or industrial heating devices or seek out industrial targets for guided missiles.

The new electric eye, only slightly larger than a pencil lead and but 3/8 inch long, is more sensitive to light than vacuum photocells a hundred times larger.

Dr. W. C. Dunlap, Jr., the scientist who designed the cell, said its acute sensitivity to infrared radiation makes it ideally suited to the regulation and monitoring of various flames and heating devices.

The unit, still in the developmental stage, has a comparatively large power output that should make it extremely useful in many industrial applications. This high-power production makes it suitable for operating relays directly, to control many production processes. Because of its power output, the new germanium device could be used for counting, sorting, and measuring applications. It could serve also in military and civilian roles as a substitute for a Geiger counter and similar atomic radiation detection devices.

The device consists of a metal cartridge housing a glass lens and a germanium wafer, in contact with a metallic button of indium. A whisker links the wafer to an outside lead. The device is called a "p-n junction photocell."

Economy Loading Simplified

J. B. WARD
MEMBER AIEE

THE PRINCIPLES of loading generating stations according to incremental rate characteristics have been known and practiced for a number of years. More recently the effect of transmission losses upon economy loading of plants has received attention. The continued rapid growth of transmission networks and system interconnections promises to bring about increased interest and emphasis on the over-all problem of operating systems at optimum economy. This article proposes to present a summary of the problem in a manner largely devoid of abstract mathematical concepts and derivations. An effort is made to establish certain principles and criteria, mainly through intuitive reasoning.

Consider a system consisting of four generating plants supplying several loads over a transmission network. The following notation is used:

P_1, P_2, P_3, P_4.... Power output in megawatts at the respective plants
C_1, C_2, C_3, C_4.... Fuel input at the respective plants in terms of dollars per hour
C_t............. Total system fuel cost in dollars per hour
P_a, P_b, P_c....... Power in megawatts consumed at loads
L.............. Total transmission loss in megawatts

It is assumed that reactive power generation is adjusted to satisfy voltage conditions, hence reactive power depends on real power loadings of sources and loads and is not dealt with explicitly. Increment changes assumed by the various quantities listed in the foregoing are denoted by ΔP_1, ΔC_1, ΔL, and so on. Plant incremental rates, or rates of change of input with respect to output, are denoted by R_1, R_2, and so on.

The total plant output must be equal at all times to the total load plus total transmission loss. In general, it is not possible to separate the output of a given plant and specify how much of this power arrives at specific load points and how much is consumed in losses.

The total input, in terms of fuel cost, is consumed (*a*) partly in useful load, (*b*) partly in transmission losses, and (*c*) partly in plant thermal losses and auxiliary power consumption. Plant losses and transmission losses are variables which depend on allocation of generation. The thermal efficiency at a particular plant depends solely on the output of that plant and is independent of the manner in which the remainder of the required generation is divided among the other plants. On the other hand, transmission losses in a complicated network are dependent simultaneously on the output of all plants. The objective is to supply a given set of loads with generation scheduled in such a way that the best over-all economy is achieved. Optimum economy will occur at some compromise between the opposing effects of station losses and transmission losses, and only in case of a very unlikely coincidence will a particular generating schedule yield simultaneously the minimum transmission loss and minimum fuel cost.

One approach to gaining an understanding of the relationships of the many variables necessary for achieving optimum loading is to visualize interchange of small increments of generation among the several plants, with delivered loads held constant. Assume that an increment increase in plant 1 output replaces a small increment of generation at each other plant in turn, where in each case the loads and the power output of all plants except the two involved in the exchange remain constant. If an operating schedule is found wherein successive transfers of an increment of generation from the respective plants to plant 1 produces essentially no change in total fuel cost, then this indicates that the schedule yields optimum economy. This criterion, as expressed in terms of finite increments, is an approximation which can be improved to any desired extent by making increments sufficiently small. The following equation gives a more useful form of this criterion:

$$R_1 = \frac{R_n}{\left(1 - \dfrac{\Delta L_{1,n}}{\Delta P_n}\right)}$$

where

R_1 is the incremental rate of the reference plant where increment increase in generation is initiated
R_n is the incremental rate, at the scheduled output, of any other plant, that is, $n = 2$, 3, or 4 in the 4-plant system
$\Delta L_{1,n}$ is the increment change in total transmission loss brought about by the increment increase in plant 1 output and resulting decrease in plant n output of ΔP_n

This equation states that optimum loading is achieved when the incremental rate of plant 1 is equal to a suitably weighted or "penalized" incremental rate of each other plant. The weighting factor for a given plant contains an incremental loss term $(\Delta L/\Delta P_n)$ defined by the transfer of a small increment of generation from that plant to plant 1 with other plant outputs and loads constant. The criterion is exact in the limit as ΔP_n approaches zero.

An alternative approach is to initiate a small change in the form of an increase in load at some particular arbitrarily chosen load point. Then this increase in load is supplied by each plant in turn, one at a time, maintaining all other plants and loads constant in each case. If optimum allocation of generation exists, the incremental cost of power delivered to a particular load point is the same regardless of which plant produces the additional generation. Again this statement becomes more precise as the size of the increments approach zero.

Digest of paper 53-397, "Economy Loading Simplified," recommended by the AIEE Committee on System Engineering and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Fall General Meeting, Kansas City, Mo., November 2–6, 1953. Scheduled for publication in AIEE *Transactions*, volume 72, 1953.

J. B. Ward is with Purdue University, Lafayette, Ind.

Submarine Cables

ANDREW BODICKY
FELLOW AIEE

TO TRANSMIT electric power across rivers and other waters, submarine cables have been used for more than 50 years. A great number of various types of cables have been installed during this period. In general, submarine cables are constructed similar to the regular underground cables with added mechanical protection in the form of armor wires.

Since the United States District Engineers have jurisdiction over navigable waters, certain requirements are specified and must be complied with before a permit is granted. Other authorities also may have special interest in such projects, and must be consulted. Hazardous locations should be avoided and special protections should be provided where there is any likelihood of damage to the cables. Protection against dragging anchors requires that the cable be buried below the bottom of the water beyond the reach of anchors. In going through a levee special membranes and waterproofing against seepage must be provided. It may be more desirable to install the cable above the seep line of the levee.

The cable at the shore must be well secured and protected not only against mechanical damage but guarded against corrosion especially at the water's edge. The supporting and anchorage of the cable should be concentrated on the armor wires. The weaving and vibration of the cable should be guarded against or reduced to a minimum both during and after the installation. The use of non-lead-sheathed cable is one answer to this problem.

The laying of the cable may be accomplished by various means, from cutting a slot in the ice, pulling it across on buoys or directly through the water, but usually from a barge or boat, or a special cable-laying boat that is available on the West Coast. The actual laying of the cable should be, if possible, a continuous operation. In swift waters the cable extending from the barge to the bottom of the river will vibrate. In order to prevent intercrystalline fatigue of the lead sheath, the duration of the weaving should be held to a minimum by constantly shifting the point of attachment of the cable to the barge. Sufficient spacing between adjacent cables should be provided to prevent simultaneous mechanical damages or fault currents damaging adjacent cables. At the far side, the remainder of the cable is removed from the reel and laid out on the barge in a figure 8. The end of the cable then is pulled ashore and as the cable is lowered into position, the slack continuously is pulled ashore.

The installation of pipes for pipe-type cables is similar to those used by the oil and gas companies. Sufficient weight must be added to overcome the buoyancy of the pipe. The protection of the pipe may consist of an insulating coating and cement covering over all. In pulling the cable into the pipe the pulling stresses must be considered and special provisions made to reduce the friction. Partly filling the pipe with oil will reduce this friction greatly.

Cable splices in the water should be avoided if possible. The time of repairing and splicing should be held to a minimum and special precautions should be taken to reduce damage of the cable either due to change of water level or vibration at the edge of the water. The regular splice is usually protected by an additional lead sleeve and a strain box to transmit the strain on the armor wires across the splice.

During installation the exact location of the cable should be recorded and usually is obtained by triangulation. The depth is measured either by soundings with a lead line or by supersonic impulse type of depth recorders. The location of the trench can be followed by the same method or followed by the diver. The installed cable can be located by an electromagnetic signal and a pickup coil through an amplifier and with the aid of a diver. However, some difficulty may be experienced when a number of cables are installed at close proximity.

In case of a failure of a paper-insulated cable and a repair is contemplated, the fault should be picked up immediately. Maintaining the cables under a definite oil pressure will reduce the amount of wet cable that will have to be replaced. Picking up the cable may be difficult, especially when the cable is buried more than 5 feet in sand or mud. Dredging may be required to uncover the cable. Faults near shore can be picked up at the shore and under running the cable to the fault. The tension on the cable must be watched carefully, for sunken barges, debris, or water-soaked logs over the cables may prevent the raising of the cable. The repair of a 66,000-volt submarine cable is shown in the title picture.

The operating records of submarine cables are as good as, if not better than, that of the regular land cables in spite of the numerous additional hazards encountered.

Digest of paper 53-386, "Submarine Cables," recommended by the AIEE Committee on Insulated Conductors and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Fall General Meeting, Kansas City, Mo., November 2–6, 1953. Scheduled for publication in AIEE *Transactions*, volume 72, 1953.

Andrew Bodicky is with Union Electric Company of Missouri, St. Louis, Mo.

Power Cable Crossings on Bridges and Viaducts

D. C. HAWLEY
MEMBER AIEE

NOT INFREQUENTLY bridges provide a means of crossing streams, highways, railroads, natural depressions, and so on, with power cables that is more economical than such alternates as submarine cable, tunnels, and underwater ductline. The number of circuits involved in the crossing usually determines whether the crossing will be an aerial cable or a conduit type of installation, and also provides a basis for determining the space and weight requirements which must be accommodated on an existing structure.

In aerial-type installations nonarmored cables may be supported by rings or hangers, or spun to a messenger cable anchored to the bridge. Steel-armored, nonleaded cables also can be supported from hangers attached directly to the bridge. For example, there is an installation of 13 3-conductor 12-kv rubber-insulated nonleaded steel-wire armored cables hanger-supported on the Rainbow bridge at Niagara Falls, which is of steel arch construction 1,400 feet long.

There are several types of conduit satisfactory for use on bridges. Most common are steel or iron pipe, fiber encased in steel or iron pipe, fiber in concrete, and transite either in concrete or with no encasement. The kind to be used may be governed by several factors: (1) the type of structure on which the crossing is to be made, that is, steel or concrete; (2) length of the bridge spans; (3) frequency of the supports; (4) whether it is a railroad or a river crossing; (5) difficulties of installation; and (6) construction costs and work hazards.

On new bridges, space for fiber ducts encased in concrete usually can be provided under or in the concrete sidewalk slab. The ductline can be included in the bridge design and installed as an integral part of the structure as in Figure 1.

Because of its inherent strength, steel or iron pipe is most often a requisite in bridge crossings. It can be obtained and installed in long lengths and relatively fewer supports or hangers are required. When lead-covered cable is used, fiber duct inside the metal pipe has desirable characteristics, one of the most important being its insulating value, thus aiding in mitigating electrolysis.

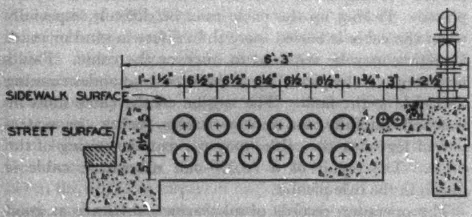

Figure 1. Ducts installed in sidewalk slab including ducts for street lighting cables

Nonleaded cables lend themselves satisfactorily to use on bridges. The insulation may be paper, varnished cambric, rubber, or rubber-like compounds. The jacket or sheath can be rubber, neoprene, or other similar material. When nonleaded cables are used, they may be installed in ducts or supported on messenger or hangers. This type of cable is light in weight and is relatively free from expansion and vibration troubles.

Lead still is used to the greater extent for power cables as the sealing and protective covering over the cable core. Lead has definite mechanical limitations, being susceptible to progressive deterioration when exposed to vibration. More frequent and faster longitudinal movement caused by the greater temperature ranges which exist on bridge crossings, together with the movement of the bridge itself (as at expansion joints), also tend to shorten the life of the lead sheath.

Failure of the lead sheath resulting from vibration is apparently the chief hazard. When leaded cables are used, the factors introduced by vibration and the minimizing of their effect on sheath life must be considered.

Vibration causes relatively little trouble to cables in conduit installed on fixed bridges of steel or concrete construction. If these structures are short and relatively stable, trouble-free operation of the cables may be anticipated. On longer overwater steel bridges of girder type, the vibration problem is more severe. Operation experiences indicate that any cushioning or shock absorbing features introduced into the design will reduce greatly the harmful vibration transmitted to the cable.

Three-conductor lead cables are used more generally, being more economical in original cost and more easily installed. More space, however, is required in manholes for expansion bends and loops than with some other types. This type is satisfactory for use in ducts and can be used with fair results for messenger installation.

The weakest point of any conduit and cable system is the cable and splices in the manholes. Cables on bridges are subjected to sudden and severe changes in ambient temperature. If a sudden lowering of the air temperature occurs coincidentally with downward trend of the load cycle, the cables may move several inches in a short time.

Bridge crossings are to be avoided if at all possible but, if required, they can be installed and operated successfully if the difficulties are recognized and provided for in the design. Inspection and maintenance routines should include special attention for such installations.

Digest of paper 53-390, "Power Cable Crossings on Bridges and Viaducts," recommended by the AIEE Committee on Insulated Conductors and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Fall General Meeting, Kansas City, Mo., November 2–6, 1953. Scheduled for publication in AIEE *Transactions*, volume 72, 1953.

D. C. Hawley is with the Kansas City Power and Light Company, Kansas City, Mo.

Universal Meter for Measuring Voltages at High Impedances, Micromicroamperes, and Insulation Resistance

W. R. CLARK
MEMBER AIEE

R. E. WATSON
ASSOCIATE MEMBER AIEE

G. C. MERGNER
ASSOCIATE MEMBER AIEE

A multipurpose instrument is described which can measure direct voltages in high-impedance circuits, small direct currents, and high resistances with good accuracy. The basic detector is a chopper-type stabilized feedback amplifier which is entirely a-c powered.

IT IS DESIRABLE to measure a voltage by a null method to avoid errors due to drawing current from the voltage source. It is also desirable to measure a current by a null method to avoid any error due to a change in current caused by inserting the resistance of the meter in the current circuit.

By using a chopper-type feedback amplifier a null-type measurement of voltage and current can be made with good accuracy. Zero stability is achieved by the chopper type of measurement, and gain stability is achieved by having sufficient gain in the feedback amplifier.[1]

To make resistance measurements the only additional requirement is a stabilized direct voltage of known value to connect in series with the unknown resistance in order to supply the current for measurement. The instrument to be described has all of these features.

VERSATILITY OF THE INSTRUMENT

THE INSTRUMENT, Figure 1, features an easily read meter with two scales approximately $5^1/_2$ inches in length. One scale is for voltage and current and the other for resistance. Two controls are provided, one to select the range of measurement and the other to select the type of measurement—voltage, current, or resistance. These controls make available ranges which have full-scale values as listed in Table I.

Table I. Ranges of the Universal Meter

Volts	Microamperes	Megohms At 10 Volts	Megohms At 100 Volts
0.5	5.0	2×10^2	2×10^3
5.0	5×10^{-1}	2×10^3	2×10^4
50.0	5×10^{-2}	2×10^4	2×10^5
500.0	5×10^{-3}	2×10^5	2×10^6
	5×10^{-4}	2×10^6	2×10^7
	5×10^{-5}	2×10^7	2×10^8

The type of measurement employed eliminates the need for a zero adjusting control. Two binding posts are provided for connecting the instrument for measurements. One of these does not require shielding, but for extremely low level measurements, shielding of the other binding post is necessary. A receptacle for a shielded plug also is provided for convenience in making connections to the sensitive terminal.

Terminals are provided (*E* in Figure 1) so that an external battery can be inserted in the circuit in order to measure resistance at any desired voltage level up to 500 volts.

To protect the user the push-button switch $M\Omega$ in its normal position applies only 10 volts to the input circuit for measuring resistances. It has to be pushed to make a measurement using 100 volts. The instrument may be used with a recorder for all ranges.

DESCRIPTION OF THE BASIC CIRCUIT

THE BASIC CIRCUIT is shown in block diagram in Figure 2 and schematically in Figure 3. The input signal is converted from a direct voltage to a 60-cycle voltage by a mechanical synchronous chopper. Since it is desirable to have a high input impedance the input tube of the amplifier is used as a cathode follower. Following this are three stages of voltage amplification.

The resulting amplification makes the power-level at the input stage so low that a d-c supply must be used for the heaters of the tube to avoid a-c pickup from this source. It is convenient to use a d-c supply on the heater of the second tube, since this procedure serves a dual purpose: it heats the tube cathode, and it helps to filter the d-c supply for the first tube.

All tubes and their associated components thus far mentioned are contained in a shielded compartment, with external connections made through lead-through capacitors. This minimizes the effects of the radio-frequency components of line transients.

The second or output synchronous converter is electronic and uses a duo-triode tube. The grids of both tubes are connected in parallel to the output of the last voltage amplifier stage. The plate of one triode is supplied with a 60-cycle voltage 180 degrees out of phase with the plate

Full text of paper 53-298, "A Universal Meter for Measuring Voltages at High Impedances, Micromicroamperes, and Insulation Resistance," recommended by the AIEE Committee on Instruments and Measurements and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Summer General Meeting, Atlantic City, N. J., June 15–19, 1953. Scheduled for publication in AIEE *Transactions*, volume 72, 1953.

W. R. Clark, R. E. Watson, and G. C. Mergner are all with Leeds and Northrup Company, Philadelphia, Pa.

The assistance of A. J. Williams, Jr., and W. G. Amey in reviewing this article is greatly appreciated.

Figure 1. Universal meter

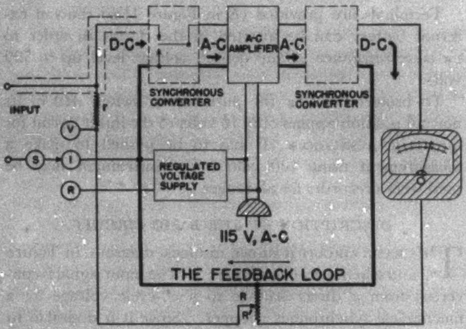

Figure 2. Block diagram of the universal meter

supply of the other triode. The converter triode having its plate voltage in phase with its grid voltage will conduct greater current than the other triode which at this time will have its plate voltage 180 degrees out of phase with its grid voltage. The voltages produced by the corresponding plate currents flowing through the cathode resistors of the tubes are added to produce the voltage output of the electronic converter. This voltage after being filtered to minimize the ripple is fed back into the input circuit to stabilize the gain of the instrument.

If the voltage is fed back in series with the detector and the input to be measured, the instrument makes a null-type measurement of voltage. Referring to Figure 2 this occurs when switch *S* is in the *V* position and *r* is open-circuited. In this case the voltage range is determined by the voltage drop across *R* produced by the current flowing in the meter.

If the voltage is fed back through a resistor and this combination is in parallel with the detector and the input to be measured, the instrument makes a null-type current measurement. This occurs when the switch *S*, of Figure 2, is in the *I* position. In this case the current range is determined by the voltage drop across *R*, divided by the value of *r*.

In order to make a resistance measurement it only is necessary to apply a known regulated voltage to the unknown resistor and measure the current through the resistor by the null current method previously described. Such a regulated supply is built into this instrument. To measure resistance, it only is necessary to turn switch *S* to the *R* position.

Sufficient stability is obtained for the regulated supply by using two successive stages of regulation, each stage employing a glow discharge type of regulator tube. The first stage uses a type *OA2* regulator tube and the second stage uses a type *5651* voltage reference tube. Since only 2 milliamperes are required, excellent regulation is obtained by this method.

Four voltage ranges are provided. The two low ranges are obtained by selecting the proper value of *R*, and hence, a direct measurement is made of the unknown voltage. For the higher ranges of voltage, a high-resistance voltage divider is incorporated in the instrument and used to attenuate the voltage to a value which then is measured by the low-range method. The six current ranges and six resistance ranges are obtained by changing the values of *r* and *R*, see Figure 3.

The push-button switch which changes the regulated voltage applied to the unknown resistance from 10 to 100 volts provides a method of quickly checking the voltage coefficient of resistance as well as supplying the higher resistance range. The instrument is calibrated for the high-resistance range using the 100-volt supply.

The type of circuit used makes the equivalent input resistances for the voltage ranges quite high, the equivalent input resistances for the current ranges fairly low, and greatly reduces the effect of input capacity in resistance measurements. For operating convenience a 10,000-megohm resistor is connected across the input for all voltage ranges.

Terminals are provided so that a null-type voltage recorder with a range of 20 millivolts can be connected across part of the *R* resistor and used for all ranges when it is desired to record measurements. A filter is incorporated in the input circuit of the amplifier to minimize the effects of spurious a-c pickup in the input leads.

In order to make measurements at high impedances, good insulation must be provided. Specially designed switches and terminals are employed using for insulation an acrylonitrile copolymer of styrene. These switches are leaf type, isolated and shielded, and are so located that the leads from the instrument input terminals to the switch and from the switches to the amplifier input are short. The high-valued resistors of the input circuit are mounted on these switches.

Plungers, Figure 4, with lucite insulating caps, activated by cams on the range switch, operate these switches.

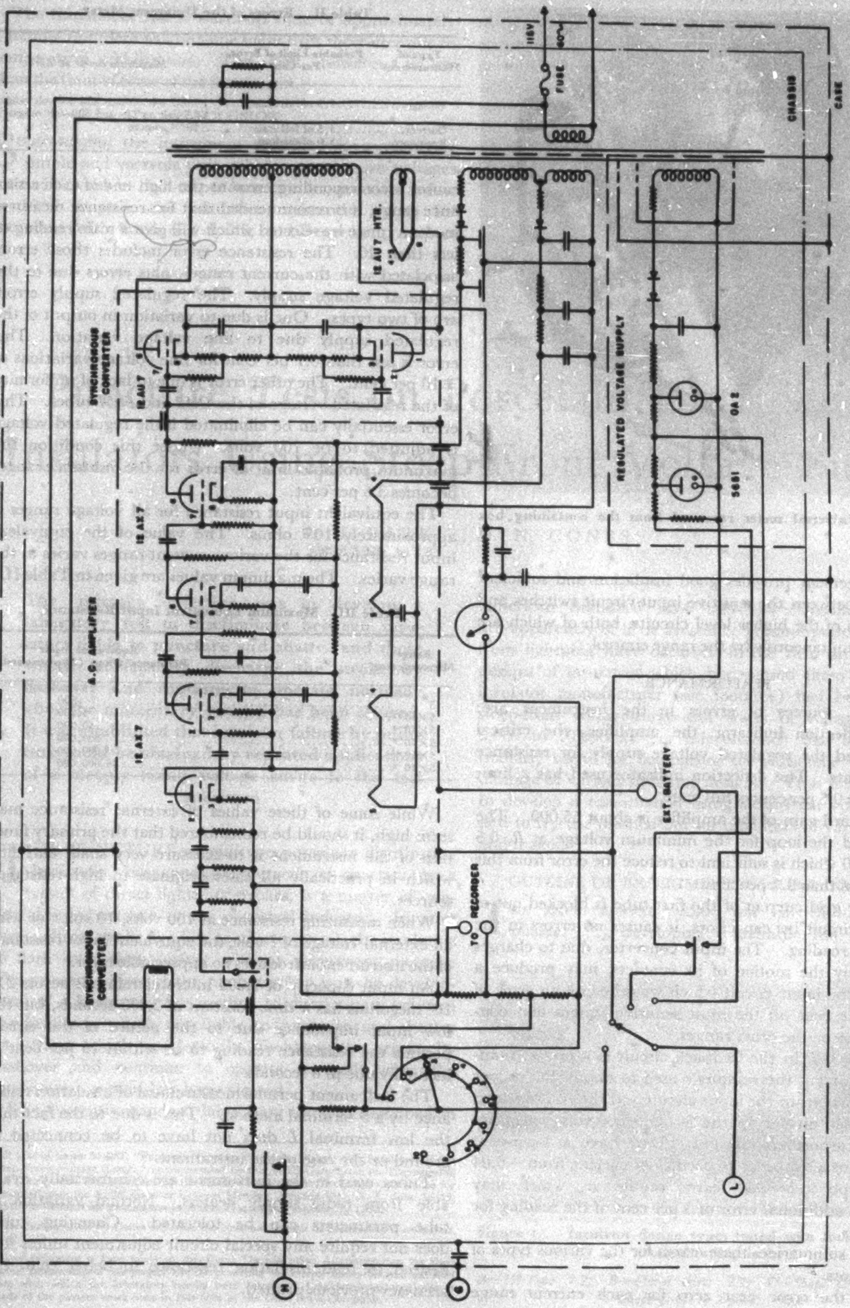
116V
60~
FUSE
CHASSIS
CASE
12 AU7 MTR.
SYNCHRONOUS CONVERTER
12AU7
12 AX7
A.C. AMPLIFIER
12 AX7
SYNCHRONOUS CONVERTER
REGULATED VOLTAGE SUPPLY
OA2
5651
EXT. BATTERY
TO RECORDER
L
H
G

Figure 3. Schematic wiring diagram of the universal meter

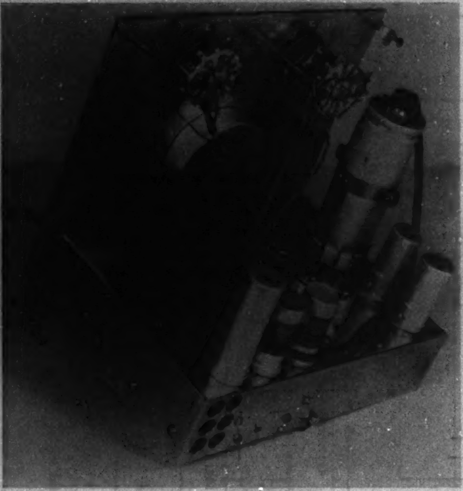

Figure 4. Universal meter removed from the containing box

This arrangement provides good insulation and sufficient separation between the sensitive input-circuit switches and the switches of the higher level circuits, both of which are operated simultaneously by the range control.

PERFORMANCE

PRINCIPAL sources of errors in the instrument are: the deflection indicator, the amplifier, the critical resistors, and the regulated voltage supply for resistance measurements. The deflection indicator used has a limit of error of ±0.5 per cent of full scale.

The forward gain of the amplifier is about 65,000. The gain around the loop for the minimum voltage at R, 0.5 volt, is 1,200 which is sufficient to reduce the error from this source to less than 0.1 per cent.

Since the grid current of the first tube is blocked out of the input circuit by capacitors, it causes no errors in the instrument reading. The input converter, due to charges generated by the motion of its contacts, may produce a current in the input circuit which would cause an error of about 1 per cent on the most sensitive ranges and considerably less on the other ranges.

The resistor R in the feedback circuit is a precise manganin resistor but the resistors r used to obtain the proper feedback currents in the input circuit and the resistors used in the voltage divider for the 50- and 500-volt ranges are deposited carbon, spirally cut. They have a 1-per-cent accuracy plus a temperature coefficient varying from −0.04 to −0.15 per cent per degree centigrade, which may produce an additional error of 3 per cent of the reading for some ranges.

Table II summarizes these errors for the various types of measurements.

Table II. Errors of the Universal Meter

Type of Measurement	Probable Limit of Error, Per Cent	Maximum Error at Zero
Voltage	1.5 of full scale	0.005 volt on 0.5- and 5.0-volt ranges 0.5 volt on 50- and 500-volt ranges
Current	3.5 of full scale	10^{-13} ampere
Resistance	5.0 of reading	

Because the error near zero for each current range causes a corresponding error at the high end of each resistance range, it is recommended that for resistance measurements a range be selected which will give a scale reading of less than 20. The resistance error includes those errors associated with the current ranges, plus errors due to the regulated voltage supply. The regulated supply errors are of two types. One is due to variation in output of the regulated supply due to line voltage variation. This error is less than 0.1 per cent for line voltage variations of ±10 per cent. The other error is due to lack of uniformity of the regulated voltage of the *OA2* and *5651* tubes. This error essentially can be eliminated if the regulated voltage is adjusted to be 100 volts. Under this condition the maximum probable limit of error for the resistance ranges becomes 3.6 per cent.

The equivalent input resistance for all voltage ranges is approximately 10^{10} ohms. The value of the equivalent input resistance for the various current ranges varies as the range varies. The maximum values are given in Table III.

Table III. Maximum Equivalent Input Resistance

Range Microamperes	Equivalent Input Resistance Ohms (Approximately)
5	500
5×10^{-1}	5,000
5×10^{-2}	50,000
5×10^{-3}	500,000
5×10^{-4}	4,900,000
5×10^{-5}	45,000,000

While some of these values of external resistance may seem high, it should be remembered that the primary function of the instrument is to measure very small currents, which in practically all cases originate in high-resistance sources.

When measuring resistance at 100 volts, 10 volts, or with an external voltage of 1 volt, the equivalent input resistance of the instrument introduces no appreciable error.

An input capacity of 1,000 micromicrofarads across 2×10^6 megohms has a time constant of 2,000 seconds, but the low input impedance due to the nature of the circuit permits the resistance reading to be within 10 per cent of its final value in 8 seconds.

The instrument permits measurement of insulation resistance by a 3-terminal method. This is due to the fact that the low terminal L does not have to be connected to ground or the case of the instrument.

Tubes used in the instrument are commercially available from radio supply dealers. Normal variation in tube parameters can be tolerated. Changing tubes does not require any special circuit adjustment unless it is desired to read insulation resistance to better than the accuracy previously stated.

The instrument has a warm-up time of approximately 1 minute but there will be some slight drift thereafter due to temperature stabilization. This drift, however, is less than the limit of error of the instrument.

CONCLUSION

Summarizing, the instrument described is a relatively simple and versatile unit, which can measure voltages up to 500 volts in high-impedance circuits, currents as low as 10^{-12} ampere, and insulation resistances up to 10^8 megohms with limits of 1.5, 3.5, and 5 per cent, respectively. The method of measurement used results in negligible errors due to insertion of the instrument in circuits. It permits measurement of insulation resistance in accordance with approved American Society for Testing Materials methods.[2]

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Puncture Tests on Porcelain Distribution Insulators Using Steep-Front Voltage Surges

J. H. PARK
MEMBER AIEE

H. N. CONES

The primary objective was to develop a laboratory test to discriminate between insulators liable to puncture and shatter and those which satisfactorily discharge the stroke by flashover and continue to operate normally after the momentary ground has been cleared. It was established that insulator failure by puncture could be obtained by repeated applications of a steeply rising voltage surge to the test specimen

THE PUNCTURE of pin-type porcelain distribution insulators, occasionally observed in practice as a result of direct lightning strokes, is a matter of considerable importance to the electrical industry. In most cases a direct stroke to a line conductor causes the insulators to flash over their surface without permanent damage. The primary object of the present study was the development of a laboratory test method to discriminate between the insulators which are liable to puncture and shatter and those which satisfactorily discharge the stroke by flashover and continue to operate normally after the momentary ground has been cleared.

The currently standard laboratory tests, as described in American Standard *ASA C29-1944* "Insulator Tests," are apparently of little assistance because puncture failures from lightning have occurred in the field on makes and designs of insulators which had passed these tests. One insulator manufacturer (see footnote) had been using a steep-front voltage-surge test (rates of voltage rise from 3,000 to 10,000 kv per microsecond) that seemed particularly useful for comparing the resistance to lightning damage of various insulator designs. Thus it was decided to develop a test method using steep-front voltage surges and to try the method out on insulators of various designs and makes.

OUTLINE OF EXPERIMENTAL WORK INVOLVED

The experimental work was carried out in two phases: (1) developing a suitable test method or

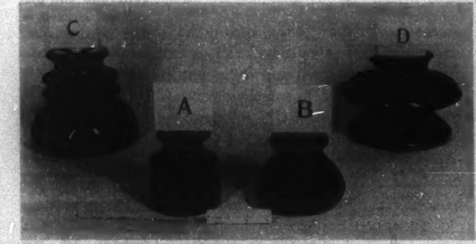

Figure 1. Insulator design types tested with their names and nominal ratings in kv:

A—Hi-Top: 7.2; *B—Flared skirt:* 7.2; *C—Shape C:* 14.4; *D—Shape D (1- or 2-piece):* 14.4

Full text of paper 53-257, "Puncture Tests on Porcelain Distribution Insulators Using Steep-Front Voltage Surges," recommended by the AIEE Committee on Transmission and Distribution and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Summer General Meeting, Atlantic City, N. J., June 15–19, 1953. Scheduled for publication in AIEE *Transactions*, volume 72, 1953.

J. H. Park and H. N. Cones are with the National Bureau of Standards, Washington, D. C.

Acknowledgment is here made to the Rural Electrification Administration for their partial sponsorship of this project and for providing the sample insulators and the field data with which the laboratory results were correlated. Acknowledgement also is made of the pioneer work done in this field by the Ohio Brass Company.

procedure and (2) applying the test method to various types and makes of new insulators for the purpose of checking its value as a comparative test. The development of a test method consisted of: (*a*) devising circuit connections and arrangements for the surge generator and its discharge circuit to obtain the required rate of voltage rise across the insulator, (*b*) trying several types and arrangements of voltage dividers in order to obtain as high an accuracy as possible in the measurement of voltage and rate of voltage rise, and (*c*) applying these steep-front voltage surges to insulators of various types and makes to find out if punctures would occur in any of the insulators. It should be noted that, experimentally, parts *a*, *b*, and *c* could not be carried out independently because, for instance, a change in voltage divider, *b*, might affect the rate of rise, *a*, and thus also affect *c*.

Comparative tests were made on new porcelain insulators submitted by 12 different manufacturers. Figure 1 shows the types submitted. Their nominal voltage ratings, dimension specifications, and accepted values of flashover voltage are shown in Table I. From the accepted values of full-wave impulse flashover voltage it may be estimated that flashover voltages of these insulators for the steep-front surges would be in the range from 200 to 500 kv.

DEVELOPMENT OF TEST METHOD

THE SURGE GENERATOR used in these tests consists of 20 1/3-microfarad capacitor units with a voltage rating of 100 kv each. As a first trial in obtaining steep waves, the surge generator capacitors were connected as usual (the 20 units discharged in series by Marx gaps) and the discharge circuit arranged as shown in Figure 2. The high-voltage lead is located at the top of the generator about 20 feet above the floor. Normally, for full-wave measurements (no flashover), the divider extends upward from the floor a distance of 20 feet to the high-voltage electrode. As seen in Figure 2, the divider height was reduced to about 9 feet and the test specimen was located close to the divider to reduce voltage drop in the leads from the divider to the test specimen. A typical cathode-ray oscilloscope record† of the voltage applied to a 7.2-kv insulator, obtained by using the circuit arrangement of Figure 2, is shown in Figure 3*A*. The initially slow rate of voltage rise seen in this record is probably caused by a combination of several factors such as (*a*) the Marx gaps not all firing at the same instant, (*b*) the charging of distributed lead capacitance through the internal generator impedance, and (*c*) stray capacitance between the generator and the discharge circuit. Whatever its source, this initially slow rate of voltage rise across the specimen undoubtedly does have an effect on its flashover voltage. By moving the final discharge gap of the surge generator from the top of the generator to a position just above the voltage divider, the cathode-ray oscilloscope record shown in Figure 3*B* was obtained. Here the initial slowly rising voltage is a much smaller percentage of the total voltage, thus pointing the way toward obtaining a useful test waveshape. The "hook" in the voltage wave as it begins to rise at a rapid rate should be noted also in Figure 3*B*. It could be that the voltage actually begins to rise in this manner, but it is more likely that the "hook" is caused by divider errors. This suggests that the stray capacitance and inductance errors of the divider must be reduced. From this starting point, numerous other surge generator circuit conditions were tried, the results of each being analyzed to indicate further desirable changes. The object at all times was to obtain a voltage wave rising abruptly from zero at a very high and constant rate until insulator flashover occurred.

Table I. Flashover Voltages and Specifications of Pin Insulators Tested*

Nominal Rating in Kv	Design Type	Maximum Diameter in Inches	Maximum Height in Inches	Flashover Voltage in Kv: 60 Cycles Dry	60 Cycles Wet	$1^1/_2 \times 40$ Positive	$1^1/_2 \times 40$ Negative
7.2	Flared	$4^3/_4$	$3^3/_4$	65	35	100	130
7.2	Hi-Top	$3^3/_4$	4	65	40	105	130
14.4	1-piece Shape C	7	$6^1/_4$	95	60	150	190
14.4	1-piece Shape D	$7^1/_2$	$5^3/_4$	95	60	150	190
14.4	2-piece Shape D	$7^1/_8$	$5^3/_4$	95	60	150	190

* Obtained from National Electrical Manufacturers Association Publication Number *42-83*, "High-Voltage Insulator Standards," November 1942.

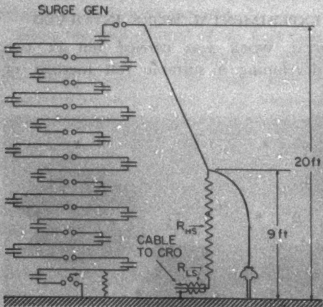

Figure 2 (top left). Connection diagram of surge generator and discharge circuit as first tried out for insulator tests.

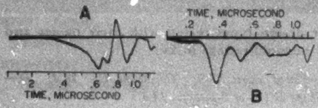

Figure 3 (lower left). Oscillograms of voltage across insulator

A—Obtained using setup as shown in Figure 2; B—Obtained using same setup except that the final discharge gap was moved to a position just above the divider

The circuit arrangement and connections finally decided upon, as giving a suitable voltage wave for these tests, are shown in Figure 4. The actual physical location of the 20 capacitor units forming the surge generator was not changed. However, the connections between capacitor units, which are normally arranged so that all 20 units are connected in series by the Marx gaps on discharge, were changed in such a way that two groups of ten units in series are connected in parallel on discharge. This reduces the maximum voltage output of the generator from 2,000 to 1,000 kv but it also reduces the effective internal impedance of the generator to one-quarter the value with all units in series. The over-all effect is to increase the rate of voltage rise obtainable. The 10,000-ohm parallel discharge resistor, R_p, serves to keep the voltage on the external discharge circuit at a fairly low value until the current in all of the Marx gaps has increased to several amperes. At that time the voltage across gap *D* rises rapidly, causing it to fire and to apply the rapidly rising voltage to the test insulator and divider. Typical records of the voltage across the test specimen obtained by using the circuit connections of Figure 4 are shown in Figure 5. For these records a total of 30 ohms was added to the internal series resistance of the generator and the external series resistance, R_s, was 70 ohms. The average rate of voltage rise on the front of these waves, measured by taking the slope of a straight line drawn through the wave front, is 7,000 kv per microsecond. By short-circuiting out the added internal generator resistance and reducing the external series resistance, R_s, to zero, rates of voltage rise up to 11,000 kv per microsecond were obtained. Figure 6 shows an example of the fastest rate of voltage rise obtained.

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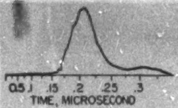
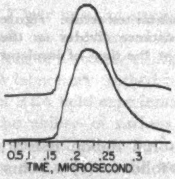
† All oscillograph records taken for these tests were obtained by use of a high-voltage cold-cathode oscillograph with beam intensification as described by the National Bureau of Standards.

Measurements of the voltage applied to the insulator specimen were made in the customary manner, using a resistance divider located as near to the specimen as possible and connecting the output of the low side of the divider to a coaxial cable going to the cathode-ray oscilloscope deflecting plates, the cable being properly terminated at the cathode-ray oscilloscope. The high side of the divider, R_{hs}, consisted of two 500-ohm noninductive wire-wound resistance cards connected in series. Each card is 2 inches wide and 8 inches long and has an inductance of 6 microhenrys as measured at 2.2 megacycles. The divider low side, R_{ls}, consisted of a 4-ohm resistor (two 8-ohm, specially constructed noninduction ribbon resistors, connected in parallel). Each ribbon resistor was made up of a nichrome ribbon 1 mil in thickness and 3/16 inch wide which was bent back on itself every 2 inches and insulated between layers with 1-mil-thick insulation. The ratio of effective inductance to effective resistance of these ribbon resistors was measured using a high-frequency bridge and found to be 2×10^{-9} at frequencies up to 50 megacycles.



A—7.2-kv insulator, peak flashover voltage = 270 kv



B—14.4-kv insulator, peak flashover voltage = 370 kv

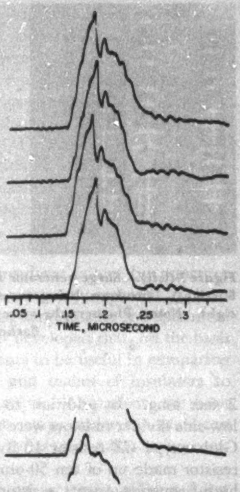


Figure 5 (left). Oscillograms of voltage across insulator obtained using Figure 4 setup with R_s = 70 ohms. Average rate of voltage rise = 7,000 kv per microsecond. Figure 6 (right). Oscillogram of voltage across a sphere gap (5-inch-diameter spheres spaced 4 inches apart). Average rate of voltage rise = 11,000 kv per microsecond. Peak flashover voltage = 400 kv

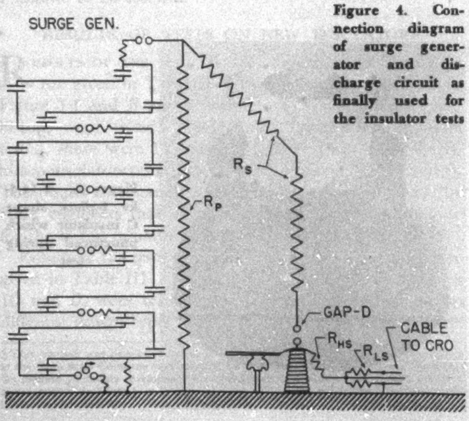


Figure 4. Connection diagram of surge generator and discharge circuit as finally used for the insulator tests

The accuracy of measurements using such a divider depends on the residual inductive or capacitive effects in both the high and low side and, probably to a greater extent, on the stray capacitance currents from various sections of the high-side resistance to nearby objects. Stray capacitance errors were minimized by keeping the total divider resistance low (1,000 ohms) and the physical size of the high-side resistors as small as possible. However, even when all known precautions are taken to minimize divider errors, the accuracy attained in measuring voltage waves with times-to-crest less than 0.1 microsecond is not definitely known.‡ In order to obtain an estimate of divider errors, the breakdown voltage of a 6-inch rod gap (using 1/2-inch-diameter rods) was measured using several different types of resistors as divider elements but keeping all other test conditions the same. In addition to the 1,000-ohm resistor made up of two 500-ohm cards, as described in the foregoing, high-side divider resistors were used as follows: (1) a 500-ohm resistor made of two 250-ohm cards in series, (2) a 750-ohm resistor made up of six 500-ohm 50-watt Ohmite number *2009* noninductive vitreous enameled resistors in a series-parallel arrangement, and (3) a 650-ohm electrolytic resistor consisting of a potassium chloride solution in a 5/8-inch-diameter tube

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‡ For the accepted standard methods for measuring steep-front voltage surges see the latest revision of AIEE Standard Number *4* "Measurement of Voltage in Dielectric Tests."

Figure 7 (left). Surge generator and insulator test setup. Figure 8 (right). Insulator being tested. Resistance divider on the right. Note: Photographs were taken at the time of insulator flashover

2 feet long. In addition to the 4-ohm ribbon resistor, low-side divider resistors were used as follows: (1) a 2-ohm Globar-type *CX* resistor 12 inches long, and (2) a 5-ohm resistor made up of ten 50-ohm *IRC* type *MPJ* Metalized high-frequency 4-watt resistors in parallel. Test results, obtained by using various combinations of these high- and low-side resistors as a divider, gave an average breakdown voltage for a 6-inch rod gap of 400 kv with a voltage wave whose average rate of rise was 9,000 kv per microsecond. The maximum deviation from the average for all of these tests was ±10 per cent. Limitation of time available for making these tests did not allow sufficient data to be taken so that a critical analysis of the performance of the various types of resistors used could be made. The 1,000-ohm card resistor for the high side and the 4-ohm ribbon resistor for low side were chosen as the divider to be used in obtaining test results because they gave results very close to the average of all divider combinations tried.

During most of the experimental work of devising a satisfactory testing setup a 6-inch rod gap was used in place of the test insulator. However, at several different stages of this work, insulator samples of various types and makes were subjected to the steeply rising surges. Thus experience was obtained on insulators with surges having rates of rise from 1,000 to 11,000 kv per microsecond. On none of these initial trials did an insulator puncture or shatter on the first voltage application even with the highest rate of voltage rise obtainable. However, several failures were noted after repeated applications of the test voltage, in some cases when the rate of voltage rise was as low as 3,000 kv per microsecond. It was concluded that a satisfactory test procedure could be devised using surges having but one selected rate of voltage rise. The significant test would consist of repeated applications of this surge at definite intervals until failure occurred or until an arbitrarily chosen number of applications or shots had been withstood. The use of only one rate of voltage rise eliminates the need of making any changes in the surge generator setup during the test. This is a decided advantage because it was found experimentally that the rate of voltage rise could not be adjusted readily, such as by changing generator charging voltage, but generally required changes in surge generator connections and the adjustment of circuit constants as well. Both positive and negative polarity surges were tried during the preliminary tests, but no significant difference in results could be noted. It was arbitrarily decided to use positive polarity surges on subsequent tests.

In order to gain more experience with this repeated shot method of test before performing the tests on new insulators, a group of 90 insulators were tested. These insulators, provided by the Rural Electrification Administration (REA), were divided into several sample groups. Some groups purposely were chosen to be of the same design and make as those which had given trouble in the field due to puncture by lightning. The surge generator and discharge circuit connections and arrangements used in these tests are those shown in Figure 4. The test setup at the time of insulator flashover is shown in Figure 7. If all added series resistance in the discharge circuit is short-circuited out, a high rate of voltage rise (up to 11,000 kv per microsecond) is obtained. However, with no series resistance to absorb the surge generator energy during discharge, a large fraction of this energy goes into the arc over the surface of the insulator. The heat of this arc causes a crazed path over the surface of the insulator which possibly could affect insulator flashover voltage on the next shot. It was considered desirable to eliminate this possibility by using the series resistance even though a somewhat lower rate of voltage rise is produced. A total series resistance of 100 ohms was added to the surge generator discharge circuit. Under these conditions the voltage across the specimen being tested rose at the rate of 7,000 kv per microsecond. Each insulator specimen was subjected to four flashovers, repeated at 1-minute intervals, except when failure occurred sooner. A close-up picture of insulator and divider is shown in Figure 8. The test insulator was mounted on a metal pin 18 inches high, with the bottom of the pin bolted to the ground return bus of the surge generator. The high-voltage or upper electrode was a 1/2-inch-diameter copper rod in the place usually occupied by the

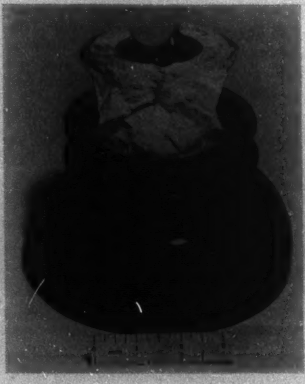

Figure 9. A 14.4-kv 1-piece shape C insulator which punctured during test

Table II. Test Results on New Insulators Rated at 7.2 Kv

Maker	Insulator Type			
	Flared Skirt		Hi-Top	
	Number Tested	Number Failed	Number Tested	Number Failed
A	12	0		
B	14	4	5	1
C	20	2	10	1
D	15	0		
E	15	1	5	3
F	15	5	5	3
G	15	0	5	2
H	15	0		
I	15	0	5	0
J	15	0	5	0
K	15	0	15	3
L	15	0	5	3
Total	181	12	60	16

Table III. Test Results on New Insulators Rated at 14.4 Kv

Maker	Insulator Type					
	Shape D, 1-Piece		Shape C, 1-Piece		Shape D, 2-Piece	
	Number Tested	Number Failed	Number Tested	Number Failed	Number Tested	Number Failed
A					12	0
B					11	0
C					12	0
D					12	0
E	12	1				
F					9	0
G	12	1			12	0
H	12	0	10	9		
Total	36	2	10	9	68	0

high-voltage conductor. A short length of number *6* aluminum tie wire was used in the customary manner to hold the rod in place on the insulator. The 1/2-inch rod extended about 14 inches in both directions from the center of the insulator. The surge voltage was applied between the copper rod and ground.

Of the 90 insulators tested, 24 failed by shattering and all failures occurred on types and makes that had been giving the REA engineers trouble in the field. The test method§ appeared to be satisfactory. The only significant changes in applying it to the tests of new insulators were an increase in the number of shots on each specimen from four to eight and a decrease in the time between shots from 1 minute to 20 seconds.

RESULTS OF TESTS ON NEW INSULATORS

RESULTS OF THE tests on 7.2-kv distribution insulators are given in Table II. Two design types, shown in Figure 1*A* and *B* and referred to as the flared-skirt and hi-top, were tested. Of the 181 flared-skirt insulators tested, there were 12 failures (6.6 per cent). Of the 60 hi-top insulators tested, there were 16 failures (27 per cent). The results correspond to the field experience reported by REA engineers that also indicated a higher failure rate for the hi-top insulators.

Results of the tests on 14.4-kv distribution insulators are given in Table III. Two design shapes, shown in Figure 1*C* and *D*, were tested. For shape *D*, there were two different design types, referred to as 1-piece and 2-piece. As indicated by the names, the 1-piece insulators are molded and fired in one piece, and the 2-piece are molded and fired in two pieces and then cemented together. No failures occurred in the 68 shape *D*, 2-piece insulators tested. Two out of 36 (5.5 per cent) of the shape D, 1-piece insulators failed and 9 out of 10 (90 per cent) of the shape *C* insulators failed. Field data obtained by the REA, since these tests were made, also indicate failure from lightning for the shape *C* insulators. A typical failure is shown in Figure 9 for a shape *C* insulator.

CONCLUSIONS

TEST RESULTS SHOW that insulator failure by puncture can be obtained in the laboratory by repeated applications of a steeply rising voltage surge to the test specimen. A laboratory method has been developed that, on the basis of REA field experience, appears to be useful in comparing the ability of various types and makes of insulators to withstand direct lightning strokes. At present, the basis of test requires the same test setup, under the same test conditions, to be used for all types and makes being compared.

Before standards are adopted for tests utilizing steep-front voltage waves, it must be demonstrated that comparable test results can be obtained in different laboratories. This cannot be done until agreement between laboratories is obtained on the breakdown voltage of sphere gaps and on rod gaps using voltage surges with rapid rates of rise.

Further studies of measurement techniques are in progress at the National Bureau of Standards. It is hoped that this article will stimulate similar work in other laboratories and that their results will be published.

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§ This method was developed before detailed information on the test method in use at the Ohio Brass Company was obtained by correspondence. Later it was found that the method previously developed at the Ohio Brass Company was essentially the same as the method described here and that comparable results were independently obtained in the two laboratories.

Wrist Radio Transmitter

This wrist radio transmitter (shown above) and a transistorized radio receiver, developed by Sylvania Electric Products Inc., demonstrate potential applications of the transistor

Prime Mover Speed Governors

P. G. IPSEN   J. R. NORTON

OPERATORS OF power generating equipment realize that it is desirable from a system control point of view to have all speed governors on their interconnected systems with reasonably similar steady-state characteristics. Normal load changes then would be shared by all units in proportion to their ratings and the action of supplementary controllers would be uniform. This would result in smaller deviation of frequency and load distribution from the desired values. Most attempts to make all prime movers on a system respond to system changes in proportion to their ratings have been confined to setting all speed governors so that they have equal steady-state speed regulation. Tests show that the response of prime movers to changes in system frequency or to the action of supplementary controllers is of a random nature and has little relation to machine rating or steady-state speed regulation. This article outlines the factors that contribute to the random nature of prime mover response and indicate how testing programs for existing units, as well as future design changes of governing systems, can produce a major improvement.

Variations in the response of prime movers to changes in system frequency or to the action of supplementary controllers are caused by differences in the dead band and in the steady-state incremental speed regulation of the speed governing systems. Tests on a representative group of machines indicate that variation of incremental regulation is the most important factor. Failure of speed governing systems to stay within acceptable limits of incremental regulation usually is caused by excessive deviations of the control valve servomotor stroke versus generator output relationship from the ideal straight line.

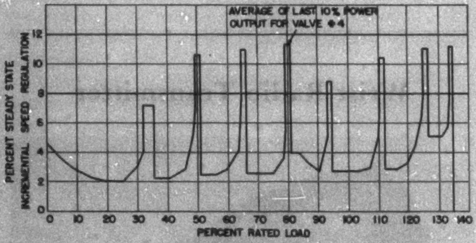

Figure 1. Steady-state incremental speed regulation versus generator output

The AIEE Standard *600* specifications for governors recommends the maximum permissible variation in incremental regulation and relates it to the generator output. This clearly defines the permissible variation but does not present a true picture of the effect of the broad regulation bands between valves because both frequency change and the action of supplementary controllers change position of the control valve servomotor without reference to the generator output. It is necessary to relate incremental regulation to the servomotor stroke if the true action of the governing system is to be evaluated. Figures 1 and 2 show the same values of incremental regulation plotted against generator output and servomotor stroke. It is evident from Figure 2 that the permissible broad regulation bands between valves have much more influence on the response of the governing system than would be inferred from Figure 1.

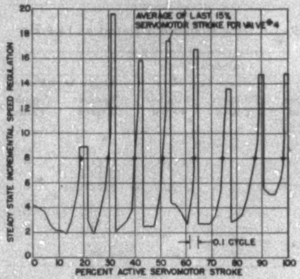

Figure 2. Steady-state incremental speed regulation versus servomotor stroke

The variations in incremental regulation permitted by AIEE Standard *600* allow bands having more than 8-per-cent regulation to exist over as much as 25 per cent of the active servomotor stroke. This is a wider variation than is desirable from a system control point of view. A significant improvement can be made by increasing the control valve intercept pressure drop a small amount. The response of good governing systems to changing system conditions changes steam and feed water flow and may cause operating difficulties which would not occur if the governor did not move the control valves. Also, emphasis on efficiency considerations may lead operators to operate purposely just below a valve cracking point where the heat rate is lowest and the incremental regulation broadest. The example presented shows that the broad regulation bands can be reduced from 22 per cent of the active servomotor stroke to 13 per cent at the expense of only 0.03 per cent in mean heat rate.

Digest of paper 53-55, "Prime Mover Speed Governors and the Interconnected System," recommended by the AIEE Committees on Power Generation and System Engineering and approved by the AIEE Committee on Technical Operation for presentation at the AIEE Winter General Meeting, New York, N. Y., January 19-23, 1953. Scheduled for publication in AIEE *Transactions*, volume 72, 1953.

P. G. Ipsen is with the General Electric Company, Schenectady, N. Y., and J. R. Norton is with the General Electric Company, Chicago, Ill.

Flux Preset High-Speed Magnetic Amplifiers

C. B. HOUSE
ASSOCIATE MEMBER AIEE

IT HAS BEEN established previously that the "firing angle" in a magnetic amplifier is governed primarily by the flux state of the core at the beginning of the gating half-cycle and that the change in the core state during the control half-cycle is fixed by the net time integral of voltage applied to the core during that half-cycle. The half-cycle response amplifier using "square-loop" material was developed in 1951 by applying this theory.[1]

It may be assumed that at the beginning of the control half-cycle, most amplifiers will be at the positive saturation level. If the flux change is controlled during that half-cycle, the flux state of the core at the beginning of the gating half-cycle has been predetermined.

It is immaterial to the results whether the tendency for flux change is caused by an applied external voltage (in square-loop materials) or by collapse of flux lines (in low-remanence materials). But the method of accomplishing this control of the flux change is dependent on hysteresis-loop shape. If the material has a high remanence, an external voltage of the proper polarity to reset the core must be applied to the winding terminals. If the material has a low remanence, it will tend to reset itself, and the external voltage must be of such a polarity and value as to permit the core to reset itself by only the desired amount.

By a positive setting of the flux level prior to the initiation of the gating half-cycle (preset) the half-cycle response amplifier may be made to operate irrespective of the shape of the hysteresis curve for the core material; that is, the ratio of remanent flux to maximum flux may possess any value between 1.0 and 0.0. A general circuit for accomplishing this purpose is shown in Figure 1.

It will be noted that the two control circuits have the same rectifier and supply voltage (e'_{ac} and e''_{ac}) polarities but that the winding polarities are opposing. Voltage applied to the core through the upper control winding will tend to drive the core in the reset direction. Voltage applied through the control winding in the dashed enclosure will drive the core towards positive saturation. This winding, therefore, can oppose any tendency of the core flux to collapse and force undesired reset. It follows, therefore, that by proper combination of voltage and resistances in the control circuits, the core, regardless of its loop shape, may be forced to any desired position on its hysteresis loop during the control half-cycle.

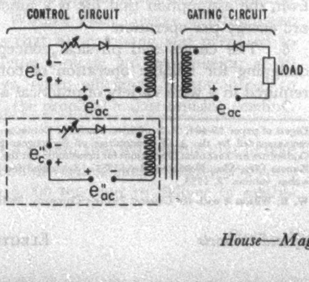

Figure 1. A general circuit for half-cycle response magnetic amplifiers

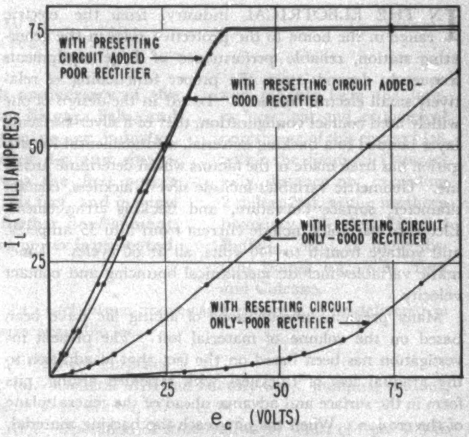

Figure 2. Transfer characteristics of half-cycle magnetic amplifier with 5–79 molybdenum-nickel-iron alloy core

An accrued advantage of this circuit which is not immediately obvious is evidenced during operation of amplifiers which employ load circuit rectifiers with a large back leakage. In former half-cycle amplifiers this rectifier leakage during the control cycle would give an uncontrolled reset when full output was desired. With this circuit, however, a cuunteracting current may be supplied by voltage e''_{ac} which will allow the core to remain saturated. One practical full-wave amplifier with square-loop material had its maximum output current increased by more than 70 per cent with the use of this circuit.

Transfer characteristics obtained when using a 5–79 molybdenum-nickel-iron core with the circuit in Figure 1 are shown in Figure 2. These curves were obtained by first operating the amplifier with the reset control windings only and then repeating the runs with both control circuits operating. This figure illustrates the effects of low remanence and large rectifier leakage in the amplifier before addition of the preset winding, as well as the compensation obtained from this addition.

REFERENCE

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Digest of paper 53-337, "Flux Preset High-Speed Magnetic Amplifiers," recommended by the AIEE Committee on Magnetic Amplifiers and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Pacific General Meeting, Vancouver, British Columbia, Canada, September 1–4, 1953. Scheduled for publication in AIEE *Transactions*, volume 72, 1953.

C. B. House is with the Naval Research Laboratory, Washington, D. C.

Life of Silver-Surfaced Contacts on Arcing Duty

W. R. WILSON
MEMBER AIEE

IN THE ELECTRICAL industry, from the electric range in the home to the protective relay in the generating station, reliable performance of large equipments frequently depends upon the proper functioning of relatively small electric contacts. To aid in the design of one widely used contact configuration, that of a silver-surfacing layer bonded to a backing material, a fundamental investigation has been made of the factors which determine arcing life. Geometric variables include silver thickness, contact diameter, surface curvature, and backing arrangement. Electrical variables include current from 5 to 35 amperes, and voltage from 6 to 440 volts, all at 60 cycles. Kinematic variables include mechanical bouncing and contact velocity.

Many previous investigations of arcing life have been based on the volume of material lost. The present investigation has been based on the fact that in addition to the gradual loss of thickness with repeated arcing, pits form in the surface and advance ahead of the general plane of the erosion. When the pits reach the backing material, this material appears in the arc gases as a vapor, and for many applications failure mechanisms are initiated. In the manometer method of test used throughout the investigation, termination of life was defined by the release of air pressure through the first puncture in the silver-surfacing layer. This was detected in turn by the dropping of a short column of mercury, which disconnected the driving motor. Although the silver foil was held against its backing material by mechanical pressure only, the data show that the test configuration is a good approximation of the practical contact in which the foil is bonded to the backing material. The method appears to be slightly conservative in that the silver thicknesses predicted probably will be a few tenths of a mil higher than required in practice.

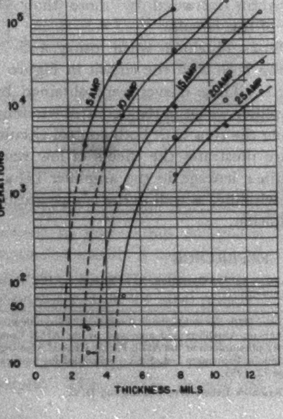

Figure 1. Life versus thickness of silver. Fixed data: $^1/_4$-inch diameter, 0.7-inch radius of curvature, 125 volts

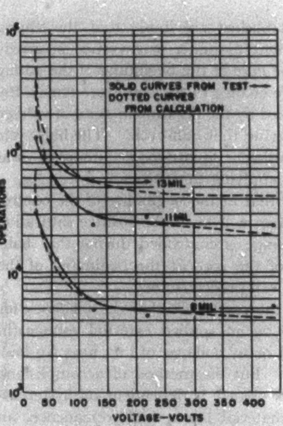

Figure 2. Life versus line voltage. Fixed data: $^1/_4$-inch diameter, flat contact surface, 20 amperes

The primary conclusions of the investigation follow:

1. Defining the termination of life of silver-foil contacts by the release of air pressure through the first puncture of the silver makes possible a convenient life-testing method which yields reproducible and significant data.
2. Concerning contact geometry, in the range covered, life increases with the 4.7 power of thickness (see Figure 1); it increases with the 1.5 power of diameter; it increases with decreasing surface curvature; and it is affected only slightly by the backing arrangement.
3. Electrically, life decreases with the 3.7 power of current; it is practically independent of line voltage from 440 to 125 volts; but it increases greatly at lower line voltages, see Figure 2.
4. Kinematically, life is reduced much more by bouncing at the break than at the make (in the absence of inrush current surges), and it is relatively insensitive to contact velocity from 0.15 to 15 inches per second.
5. The forms of the measured relationships between life, line voltage, and bouncing duration can be calculated from the assumption that life is a function of the average arc energy per operation.
6. The curves and physical concepts can be used in designing for reliable operation of contacts over the life required in a wide variety of practical applications.

Digest of paper 53-404, "Life of Silver-Surfaced Contacts on Repetitive Arcing Duty," recommended by the AIEE Committee on Switchgear and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Fall General Meeting, Kansas City, Mo., November 2–6, 1953. Scheduled for publication in AIEE *Transactions*, volume 72, 1953.

W. R. Wilson is with the General Electric Company, Philadelphia, Pa.

Niagara Falls

60 Years of Power

C. A. POWEL
FELLOW AIEE

This year marks the 60th anniversary of the development of power from Niagara Falls, and consequently of the electric power industry. Although there were earlier d-c and single-phase stations, Niagara was the first power utility. In recognition of this fact, and in view of recent proposals for its further development, this timely history of Niagara power is presented.

SIXTY YEARS AGO the Cataract Construction Company placed an order with the Westinghouse Electric and Manufacturing Company (now the Westinghouse Electric Corporation) for electric generators to be operated from power derived from Niagara Falls. There are several reasons why this fact is worth recalling today. Most people do not realize that our electric power industry is no more than 60 years old. Certainly many d-c and single-phase generating stations were in operation in 1894, but these were primarily lighting enterprises. Niagara was the first polyphase system and the first whose primary purpose was transmission for power utilization. Then also, a tribute to some of the men who undertook this development would seem to be in order on the occasion of its diamond jubilee, and finally the recent proposals to develop additional power at Niagara should be of interest in view of its past history.

DEVELOPMENT OF A PLAN

IN 1887 THE New York State legislature granted to the predecessor of the Niagara Falls Power Company a franchise to develop the water power of the Falls. Jacob F. Schoellkopf was the first president of the power company and his family has been connected with it intimately ever since. The Cataract Construction Company, with Edward A. Adams as president, was formed to carry out the development. In 1889 Mr. Adams organized an International Niagara Commission with Lord Kelvin as chairman "to conduct a scientific symposium on the development of power at Niagara Falls." Some idea of the esteem in which electricity was held in those days is indicated by the fact that the first four proposals submitted to the company for transmission of power from the Falls to Buffalo, N. Y., recommended compressed air.

In 1893, as a result of the success of the 2-phase installation at the Chicago World's Fair, George Westinghouse wrote to Mr. Adams that his company was prepared to present a plan involving 2-phase a-c transmission at 30 cycles. In these days, when efficiency is guaranteed to tenths of one per cent, the proposal makes amusing reading. It stated:

"We are to lay out a system that will enable you to take energy at the upper end of vertical shafts making 250 rpm, each shaft delivering 5,000 hp, and to deliver in salable and reliable form the largest practical and economical percentage of this energy; 1st, within the limits of Cataract City, distance not exceeding 2 miles; 2nd, at the northern boundary of the City of Buffalo; 3rd, at more distant points, e.g. New York and Chicago.

"In each of the above cases energy is to be delivered in form available for:

1. Power Purposes
(*a*). General Mill and Factory work, pumping stations, etc.: units of from 10 to 1,000 hp.
(*b*). Operation of street railways: units of from 100 to 1,000 hp.
(*c*). Miscellaneous work in factories, mills, the operation of elevators, printing presses, etc.: units of from 1 to 25 hp.
2. Lighting Purposes
(*a*). Arc lights
(*b*). Incandescent lamps
3. Electrolytic Purposes

"It is proposed ultimately to locate 25 5,000-hp turbines at the powerhouse on the American side of the river and upon the Canadian side of the river an as yet undetermined number of units of equal size. The distance between the power stations, by way of the Suspension Bridge, is 2.5 miles, and it is desired to provide electrical connection between the stations so that the generating apparatus in one station may in time of emergency be substituted for that in the other."

Mr. Adams, who had been much impressed by the Chicago, Ill., installation, sent his chief advisors, Dr. Coleman Sellers and Professor Henry A. Rowland, of Johns Hopkins University, to Pittsburgh, Pa., to investigate the facilities of the Westinghouse Company. Following this visit, the Cataract Company reported to the Niagara Falls Hydraulic Power and Manufacturing Company in October 1893: "As a result of our deliberations we have come to the conclusion that of the various bids submitted to us your interests will best be served by accepting the offer of the Westinghouse Electric and Manufacturing Company."

At the time the order for the generators, transformers, motors, and so forth, was placed with Westinghouse, a

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C. A. Powel, AIEE past president, is a lecturer on the faculty of the Massachusetts Institute of Technology, Cambridge, Mass.

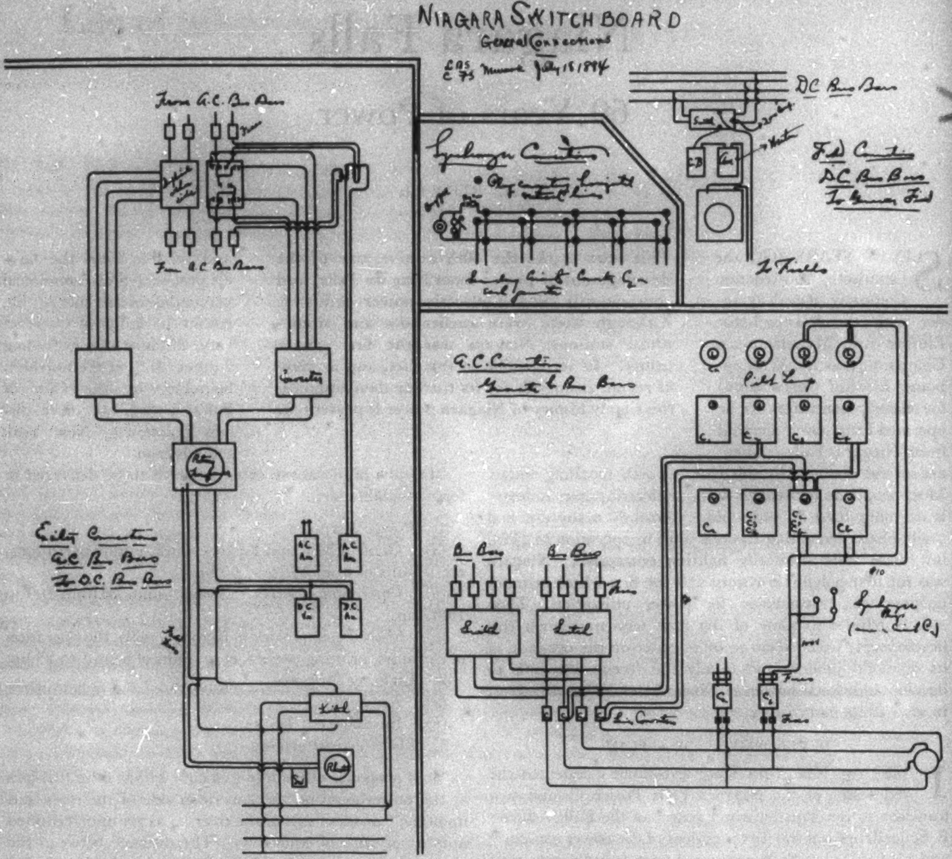
NIAGARA SWITCHBOARD
General Connections
July 18 1894
From A.C. Bus Bars
From A.C. Bus Bars
DC Bus Bars
Synchronizer Connections
Field Connections
DC Bus Bars
To Generator Field
To Tinello
A.C. Connections
Generator to Bus Bars
Pilot Lamp
Exciter Connections
A.C. Bus Bars
To D.C. Bus Bars
Converter
A.C. Am.
D.C. Am.
Bus Bars
Bus Bars
Switch
Switch
Fuse
Fuse
Synchronizer
Rheo.

Figure 1. Original wiring diagram, dated July 18, 1894, for development of power at Niagara Falls

design of the generators already had been laid out by Dr. Sellers and Professor George Forbes of London, England. This design was turned over to the Westinghouse Company and carefully examined by Albert Schmidt, the mechanical engineer of the company, and Benjamin Lamme and Charles F. Scott, the electrical designers. It fixed the general type adopted for the ten generators built. It was a vertical-shaft machine with fixed armature and external rotating field with the poles carried inside the field ring. It had eight poles, giving $16^2/_3$ cycles at 250 rpm. This low frequency was chosen by Professor Forbes to make possible the use of commutator motors. However, the Westinghouse Company had been working on the problem of frequencies and their experiments with Tesla motors and rotary converters at 30 cycles were very promising. Consequently, they strongly recommended 30 cycles in place of $16^2/_3$ cycles, and the records indicate many arguments as to the relative merits of the two frequencies. Eventually a compromise was reached with the adoption of 12 poles giving 25 cycles at 250 rpm. The original 8-pole design of Professor Forbes was for 20,000 volts for direct transmission to Buffalo. This enormously high voltage was protested vigorously by Lamme and Scott and the more reasonable figure of 2,200 volts adopted.

Many years later Mr. Lamme reviewed the Commission's original 8-pole design with the superior knowledge then available, and found that it was even worse than he and Scott had suspected. The insulation was totally inadequate for 20,000 volts and the total dissipating surface of the coils was only one-tenth of what modern practice demands. Mr. Lamme calculated that the temperature of the machines would have gone up to somewhere between 300 and 500 degrees centigrade. From the standpoint of armature reaction and reactance, the design was very bad.

Had the machines been built to the original design, the poor results well might have retarded for a long time the development of polyphase transmission.

In the machines actually built, the armature winding was distributed in a large number of slots with only two conductors per slot. By this means the heat-dissipating surface of the coils was enormously increased and the problem of insulating the coils came within the range of existing experience. Even so, fearing unknown conditions of temperature because of the size of the machines, the designers decided to use almost solid mica wrappers for insulating the parts of the armature conductors imbedded in the core. This radically new insulation was a development of C. E. Skinner. It was expensive and difficult to apply at that time but it was considered excellent insurance and well worth the price.

The ventilation of the machines also was figured out quite carefully according to the best data available, the armature core being provided with numerous ventilating passages for the cooling air. However, the engineers missed rather badly because of the enormous eddy current losses in the solid copper conductors used. There was little information and no means at hand in those days for calculating such eddy current losses.

The Niagara Falls machines led the way toward modern types of alternators in many respects. They were true polyphase generators with both phases inside a single frame, unlike the Chicago "twin-type" generators which had two single-phase armatures mounted side by side on a common shaft, staggered 90 electrical degrees with respect to each other. They were of the rotating field construction which is now universal, whereas the standard machines of that time all had rotating armatures. The external field with internal armature, however, did not persist. It was expensive in material and difficult to manufacture, and did not lend itself to natural ventilation. It was on these machines that Lamme and Scott developed a method of calculation which is fundamentally what is used today. The flux distribution and electromotive-force waves of the conductors were determined analytically and later ingeniously checked on the test floor.

THE MEN BEHIND THE PLAN

THE MAN who carried the responsibility for the performance of this revolutionary equipment which was to transmit power to "distant points, e.g. New York and Chicago" was, of course, George Westinghouse, but on whom was he relying? His chief electrical engineer was Lewis Stillwell, 30 years of age. To Stillwell must go a great deal of the credit for the adoption of alternating current at Niagara Falls. His enthusiasm and persuasiveness did much to sell Mr. Adams on the idea despite opposition from powerful and influential persons advocating direct current; Benjamin Lamme and Charles F. Scott, who were chiefly responsible for the designs of the machines and transformers, were both 29 years of age; C. E. Skinner was 28; Paul Lincoln, John Whitehead, and William Dunlap, who supervised the installation and put the electric equipment in service, were 25, 23, and 23 years old respectively.

Figure 1 shows the wiring diagram they had for the job, duly initialed by L. B. Stillwell and C. F. Scott. The diagram is divided in four parts with proper respect for economy in paper. Lettering was apparently also a waste of time. It is interesting to note that "transformers" at that time were "converters," and "converters" were "transformers." An oversight which today seems extraordinary was that no provision was made for starting up the station electrically. The excitation was from rotary converters supplied from the generators, but everyone overlooked the fact that a separate source of direct current would be necessary to energize the generators initially. Fortunately, the Cataract Company had a small d-c generator that proved suitable for the purpose.

As might be expected, a large proportion of the young men who took a leading part in the Niagara Falls development became prominent in business and education in later life, and this is true not only of those engaged in the electrical work, but also of those engaged in the utilization industries—men such as Frank Tone with the Carborundum Company; Max Mauran with the Castner Alkali Company; William Kennan with Union Carbide.

Scott, Stillwell, Lincoln, Skinner, and Whitehead became presidents of AIEE. Scott finished his career as head of the electrical engineering department at Yale; Lincoln held the same position at Cornell; Whitehead became dean of engineering at Johns Hopkins; and the others held equally distinguished posts.

The development of Niagara Falls is an example of an undertaking conceived and nurtured by private enterprise, designed and accomplished by men of vision, who were willing to accept enormous risks in the hope of completing a successful development. This enterprise enjoyed such outstanding success and efficiency that it has attracted a vast industry to its area to utilize this low-cost power.

Radio Disturbance Warnings

Beginning January 5, 1954, the National Bureau of Standards will broadcast short-term radio propagation forecasts for the north Pacific area from its standard frequency broadcasting station *WWVH*, on the island of Maui, Hawaii. The disturbance notices tell users of radio transmission paths over the north Pacific the condition of the ionosphere at the time of the announcement and how good or bad communication conditions are expected to be for the next 12 hours. The forecasts are transmitted by *WWVH* in Morse code twice each hour—9 and 39 minutes past the hour—on standard frequencies of 5, 10, and 15 megacycles.

The announcement consists of a letter and a digit. The digit is the forecast of the radio propagation quality on typical north Pacific transmission paths during the 12 hours after the forecast is made. The letter portion identifies the radio quality at the time the forecast is made at the station in Anchorage, Alaska.

These forecasts apply only to short-wave radio transmissions over paths near the auroral zone.

A New Control for Heavyweight Rapid-Transit Cars

I. W. LICHTENFELS
MEMBER AIEE

AN ADVANCE on the original combination of electric-operated cam controller with pneumatic circuit contactors, this new system utilizes two motor-operated controllers; one to establish main circuits, and the other to commutate resistance. Refinements, introduced as the result of operating experience with equipment of the previous type, give smoother operation and improved dynamic braking characteristics. Compactness and ease of maintenance have been achieved to a marked degree.

The control system, as pictured in Figure 1, is an all-electric type and includes an all-electric notching system. Switching operations, except for protective devices, are accomplished with two motor-operated controllers. A relay panel mounts the auxiliary devices necessary to translate the wishes of the motorman into operation of main switches. The entire design is based on the premise that the purpose of a control system is to achieve the rapid but smooth movement of people.

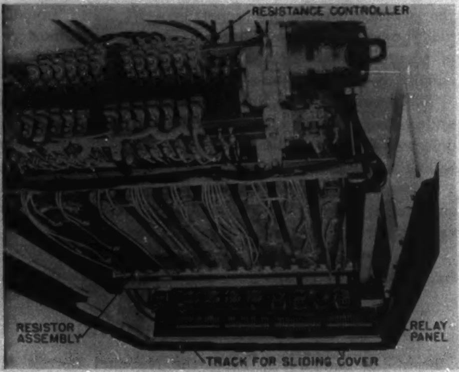

Figure 1. View of control package from under side with sliding cover removed

Since the new control must operate in mixed trains with other equipment, the train-line functions closely follow those of previous equipments.[1] Similarity ends here, however, since the two motor-operated controllers are used, instead of individual switches.

Smoothness of operation is obtained by using sufficient steps scientifically proportioned to eliminate noticeable jerk on any notch. In applying and removing power, the change of rate is maintained at its best value by controlling the speed of the pilot motors driving the controllers.

"Skip Bridge" transition, introduced for the first time, provides a means of obtaining a smooth motor transition regardless of the accelerating rate. Sufficient parallel resistance is provided to make a smooth transition at low rate. For higher rates smooth operation is obtained by eliminating steps as required to produce transfer without changing motor torque.

Increased reliability of dynamic braking has been achieved by maintaining the control power source locally rather than depending on train line circuits.

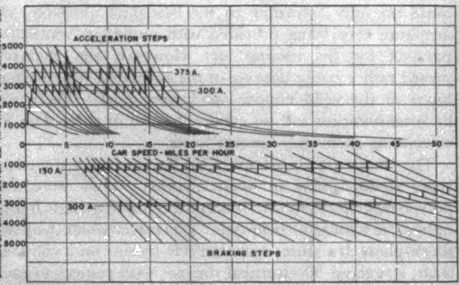

Figure 2. Notching curves for motoring and braking

Traction motor protection, particularly during high-speed dynamic braking, has been increased greatly by a better overload device and circuit design.

Field forcing of traction motors during shunted field dynamic braking provides fast but smooth brake response without overshooting.

The use of blown resistors gives high capacity with light weight.

High utilization of the control system components results in a basic simplification. For example, the circuit controller with one drive unit is used to establish power, coast, and brake circuits; and, in addition, it functions as a reverser and field shunter.

Reduction in maintenance costs is achieved by using cam-operated switches, designing all control relays with identical mechanical components, and providing sealed lubricated bearings. The apparatus layout and housing permit easy access for adjustment and maintenance.

REFERENCE

1. A New Lightweight Rapid-Transit Control Equipment, I. W. Lichtenfels, H. G. Moore. AIEE *Transactions*, volume 70, part I, 1951, pages 224–6.

Digest of paper 53-51, "A New Control for Heavyweight Rapid-Transit Cars," recommended by the AIEE Committee on Land Transportation and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Winter General Meeting, New York, N. Y., January 19–23, 1953. Scheduled for publication in AIEE *Transactions*, volume 72, 1953.

I. W. Lichtenfels is with the General Electric Company, Erie, Pa.

Characteristic Power Requirements in Underground Coal Mines

H. P. MUSSER
MEMBER AIEE

The power consumption in underground coal mines as related to connected horsepower for certain operations or areas is discussed. All the data presented are based upon actual tests extending over a long period of time and represent the average figures for many mines unless otherwise stated.

MANY CHANGES IN coal mining methods have been taking place during the past 2 decades as a result of mechanization. Electric motor drives now are used for a great variety of functions. In order to design proper underground power transmission and distribution circuits, to select the correct size and location of transforming or converting units, and to estimate power supply needs and costs, it is desirable to determine typical demand and energy consumption requirements for both individual operations and area needs.

The size of a motor used to operate certain mining equipment does not necessarily fix the demand and energy consumption that might be expected in comparison to similar requirements of other smaller or larger motors. There are many factors affecting the demand and energy consumption per connected horsepower, such as the type and condition of a particular piece of equipment, the rate at which a mining operation is performed, and the human element of handling equipment. The data assembled from many tests and studies show sufficiently consistent results to draw definite conclusions regarding demands and energy consumptions related to horsepower ratings for performing various functions in underground mining.

THE TORTOISE AND HARE RACE OF TONNAGE AND POWER

AN EXCELLENT WAY TO illustrate the growth of mechanization in coal mining is to compare the tons of coal produced per horsepower connected at two widely separated periods. For instance in 1931 a group of 23 companies with outputs in the 30,000- to 60,000-tons-per-month class produced an average of 30.22 tons of coal per month for each horsepower in electric equipment connected, whereas in 1951 a similar group in the same tonnage class produced only 16.39 tons for each connected horsepower. Naturally, as the amount of connected load increased the over-all demand and energy consumption followed in nearly direct proportions, but in certain individual applications or mining operations the demands and energy requirements are more or less constant and do not change with changes in rated horsepower.

All data presented are based upon actual tests extending over a long period of time. Unless otherwise stated, all values apply to the demand and energy consumption at the face. These values of necessity are less than those registered at the metering point or center of distribution because of transmission, conversion, and transformation losses.

MINING MACHINES

Power Requirements as Related to Connected Horsepower. The mining machine used to cut coal at the face is the one piece of equipment which was used almost universally in bituminous coal mines before the automatic miners such as Colmol, Continuous Miner, and others made their appearance several years ago. It is still the piece of machinery common to more mines than any other item of equipment unless fans are considered.

Actual tests have shown that the demand and energy requirements of mining machines do not vary with the horsepower rating as directly as might be expected. In fact, a mining machine of 50-horsepower rating normally will create demand and consume energy in quantities just slightly larger than a 35-horsepower machine (see Table I).

It is obvious that energy consumption figures for mining machines based on tonnage would provide no true basis of comparison between cutting coal in a seam 3 feet high and in a seam 6 feet high. The only basis of comparison for power consumption by mining machines is in energy used per square foot of kerf. Kerf is defined as the undercut (or other types of cuts) made to assist the breaking of the coal. For example, if the mining machine has a 6-foot cutter bar and is undercutting a face 20 feet wide there would be 120 square feet of kerf. For convenience the term watt-hours per square foot of kerf will be used.

By referring to Table I the marked similarity in demand and energy requirements can be noted between the 35- and 50-horsepower mining machines. The low energy consumption as listed in the table for the 65-horsepower machine is not representative of that horsepower rating because all of the tests for that category were made in one seam which is more easily cut than the average. The 75-horsepower mining machine created a larger demand than the machines of lower horsepower rating but the energy consumption for a definite unit of work performed was almost identical. This is exactly as it should be since demand, expressed in kilowatts, is a measure of the rate of doing

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Full text of paper 53-360, "Characteristic Power Requirements for Performing Various Functions in Underground Coal Mines," recommended by the AIEE Committee on Mining and Metal Industry and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Middle Eastern District Meeting, Charleston, W. Va., September 29–October 1, 1953. Scheduled for publication in the AIEE *Transactions*, volume 72, 1953.

H. P. Musser is with the West Virginia Engineering Company, Charleston, W. Va.

Table I. Variation of Power Consumption With Rated Horsepower of Mining Machines

Connected Horsepower	Number of Places Cut	Number of Seams	Average Demand in Kw	Average Watt-Hours Per Square Foot Kerf
30	6	1	19.54	32.84
35	20	7	27.16	46.77
50	22	4	28.54	47.16
65	68*	1*	24.82*	31.32*
75	17	1	41.47	48.95

* This seam of coal easier to cut than the average seam

Table II. Variation of Power Consumption With Age of Bits (65-Horsepower Mining Machine)

Age of Bits	Number of Places Cut	Average Demand in Kw	Average Watt-Hours Per Square Foot Kerf
Worn out	13	25.94	37.80
Half used	8	25.11	25.60
New	5	24.33	18.50

work and the watt-hours, required to cut a square foot of kerf, are a measure of a definite amount of work done regardless of the time required for doing the work. By contrast with the power consumption data as shown in Table I, one 75-horsepower mining machine cutting 20 places in the Chilton seam where sandstone streaks existed, used an average of 142.39 watt-hours per square foot of kerf or almost three times as much energy. This clearly illustrates the range of energy use that is possible under varying conditions. However, many tests by machines of different horsepower ratings in a variety of seams substantiate the generalization that cutting coal under normal conditions with ordinary bits consumes about 50 watt-hours per square foot of kerf.

Power Requirements as Affected by Type and Condition of Bits. Table II outlines the variation of power consumption with the new or worn condition of bits used on the mining machine cutter-bar chain. The mining machine using new or sharp bits consumed less than one-half the energy of the machine using old worn-out bits. This illustrates quite strikingly how bit sharpness affects energy consumption. However, in contrast, the demands created by machines using new, half-used, or worn-out bits were almost the same. This indicates that the dull bits do not consume power at a faster rate but because of the bit dullness the machine must operate for a longer period of time to make the cut, thereby using more energy. The demand or rate of using power remains about the same but the time element increases the energy consumption required to cut a unit of kerf when dull bits are used.

As might be expected in the operation of mining machines, energy consumption varies considerably with the use of different types of bits but to one's surprise the demand does not vary in a similar manner. Table III shows this variation quite clearly with one type of bit using almost twice the energy used by another type. Several different types of bits are in general use for mining machines: namely, a bit which is used and then resharpened repeatedly by heat treatment; a bit which is used once and then thrown away; and several types of bits which are tungsten carbide tipped and hold their cutting edge so well that they can be used for cutting considerably longer than any of the other types before resharpening. Only small variations in demand are caused by using different type bits and therefore the energy variation results from the time required to cut a place. The tests outlined in Tables II and III both were made with a 65-horsepower mining machine and were a part of the 68 places cut by the 65-horsepower machine in Table I in a seam which is easier to cut than the average coal seam, thereby accounting for the low power consumption figures. Although these figures are not representative power consumption figures they reflect quite accurately how energy use varies with bit dullness and with different types of bits.

LOADING MACHINES

ALTHOUGH THERE HAVE BEEN numerous machines designed through the years to load coal, the modern-type loading machines in general use today came into wide acceptance in the bituminous coal industry about 1935. Since that time there has been a trend to wider use of loading machines as mechanization at the mines increased and although the automatic miners made their appearance about 1948 the loading machine still is used widely. Even though the automatic miners were designed to replace the loading machine as well as the mining machine and drill, in practice it is observed that many loading machines are operating behind automatic miners so that the room floor can act as a surge bin and thereby permit the automatic miners more nearly to fulfill their mission, that is, continuous operation. This practice is in use because the coal hauling facilities at many mines do not remove the coal from the automatic miners as rapidly as it is mined.

Actual tests over the years have shown that between 0.35 and 0.5 kilowatt-hour per ton is required by loading machines. As was found with mining machines the energy consumption for loading machines does not vary directly with horsepower rating.

Table IV outlines the results of tests where three different types of loading machines of varying horsepower ratings were operated in the same mine. It should be noted that the demand figures listed in this table were recorded at the substation and therefore are slightly higher than the demands at the face because of transmission losses. The loader type number *1* with 20-horsepower rating created the lowest demand of the three types but used the most energy. The explanation for this fact is that the machine operates slower creating less demand, but takes longer to load a ton of coal and thereby uses more energy. Loader type number *2* created a much higher demand than the other two loaders as a result of the manner in which it loads coal but, operating considerably faster than loader type number *1*, it consumed less energy to load a ton of coal than the number *1* type. Loader type number *3* with much the largest horsepower rating consumed the least energy of any of the three types and created only slightly more demand than number *1* loader. This number *3* loading machine is faster in its operation than number

1 loader, therefore uses less energy and its operating cycle is smoother than type number *2* and creates much less demand.

AUTOMATIC MINERS

About 1948 two automatic miners were placed on the market: one, the Continuous Miner, was built by Joy Manufacturing Company and the other, the Colmol, was built by the Jeffrey Manufacturing Company. Since that time several other manufacturers have built machines designed to do the same job. These machines were planned to replace the mining machine, drill, and loading machine and to cut and load the coal in one operation. These automatic miners created new electrical problems as soon as they began operation. W. A. MacCalla lists these problems as:

1. The miner combines in one operation what were formerly three separate machine operations: cutting, drilling, and loading. When "all eggs are in one basket," as in the continuous miner, any stoppage means total loss of production. As ways are devised to make these miners more truly "continuous," this problem becomes increasingly important.
2. The rate of advance of the miner is comparatively rapid, requiring corresponding measures for rapidly advancing the electric system.
3. We have far more horsepower in the continuous miner than formerly concentrated in any one machine. In a system where several miners are operating in a limited area, the concentration of power is quite considerable.

It is extremely important to maintain a good voltage supply to these machines since the torque requirements are considerable and for a special reason with machines operated by direct current. Since under d-c operation motor speed is a function of voltage, it follows that voltage means tonnage. In fact, one company raised the voltage 18 per cent and the tonnage increased nearly 50 per cent. The automatic miners are an ideal application for a-c power and as long as the voltage is maintained above the critical "pull-out" level the motors operate at practically constant speed. The importance of maintaining good voltage regulation for the supply to a-c motors is emphasized by the fact that the torque of an a-c motor varies as the square of the voltage.

The automatic miners are rated between 150 and 631 horsepower. In a series of ten tests using two of the automatic miners, the average energy use was 2.25 kilowatt-hours per ton. The average demand created in two tests, each in a different seam, for one automatic miner was 87.5 kw. The average demand created in seven tests in four different seams for another automatic miner was almost identical being 86 kw.

One test was made at a substation feeding a complete extraction unit having a total connected load of 285 horsepower which consisted of an automatic miner and gathering and haulage conveyors necessary to transport the coal to the tipple. Naturally taking data at the substation means the transmission losses will be included and therefore both the energy and demand values are higher than would be the case for values taken at the face. This test was recorded for a period of $6^{1}/_{2}$ hours during which the automatic miner advanced 80 feet in a coal seam $3^{1}/_{2}$ feet high and at a face 20 feet wide. The energy consumed by this 285 horsepower of connected load was 4.18 kilowatt-hours per ton at the substation.

GATHERING

Three primary methods are used to gather the coal from the faces where it is mined and to deliver it to the main haulageways. These are by rail, by either chain or shaker conveyors, and by shuttle cars. Energy use for either method varies between 0.25 and 0.5 kilowatt-hour per ton under average conditions without appreciable difference between the methods. However, in considering demands a difference is found, since gathering locomotives would create demands in excess of conveyors or shuttle cars.

One demand test made on a face chain conveyor 50 feet long with a 5-horsepower motor driving it showed the average demand to be 2.3 kw. To operate this same conveyor empty required 1.3 kw or 56.5 per cent of the average demand created while moving coal. This load, measured when the conveyor was empty, is the friction load which was smaller for this installation than normally is found.

On another demand test made on a room chain conveyor 260 feet long, driven by a 10-horsepower motor, the average demand was found to be 7.38 kw or almost the rated capacity of the motor. On this installation momentary overloads occurred. The load required to drive this chain conveyor empty was 5.2 kw or 70 per cent of the average demand created while moving coal which is a normal condition for chain conveyors. This forcefully demonstrates the magnitude of friction loads normally experienced with conveyor operation.

An interesting experiment in power use for gathering coal by rail was made in which two gathering locomotives were used, one rated at 3 miles per hour and the other at 6 miles per hour. Both locomotives were rated at 60 horsepower, the slow-speed one having motors operated in series and the fast-speed one using motors operating in parallel. The results of this test are outlined in Table V and show how greatly energy consumption can vary with locomotives of the same horsepower operating with different motor

Table III. Variation of Power Consumption With Different Type Bits (65-Horsepower Mining Machine)

Type Bit	Number of Places Cut	Average Demand in Kw	Average Watt-Hours Per Square Foot Kerf
Type Number 1	5	24.33	18.50
Type Number 2	18	22.67	29.70
Type Number 3	15	25.63	32.90

Table IV. Variation of Power Consumption With Rated Horsepower of Loading Machines

Type Loader	Connected Horsepower	Substation Demand	Kilowatt-Hour Per Ton
Type Number 1	20	10	0.423
Type Number 2	25	20	0.405
Type Number 3	50	12	0.364

connections. It will be noted from the table that the parallel-connected locomotive rated at twice the speed of the series-connected locomotive actually gathered less coal and consumed more than twice the energy per ton. This condition exists because with the faster speed there is more spinning of the wheels, extra power required for acceleration, and considerable power wasted in the resistances (running on points).

Table V. Power Use for Gathering Coal With Locomotives Operating in Series or in Parallel (60-Horsepower Locomotives)

Motors Connected	Rated Speed in Miles Per Hour	Tons Gathered Per Day	Energy Use Per Day (Kilowatt-Hours)	Kilowatt-Hour Per Ton
Series	3	176.3	54.2	0.307
Parallel	6	154.8	108.2	0.698

CONVEYOR LOADING SECTION

MANY MINES OPERATE sections in which the coal is cut, drilled, and shot in the traditional manner and then loaded by hand onto chain conveyors. A test was made on such a section to determine the demand and energy requirements. This section contained the following equipment with the horsepower ratings as indicated:

Equipment	Horsepower
4 mining machines	140
4 face conveyors	20
2 room conveyors	20
2 blowers	6
1 car hoist	5
4 coal drills	6
Total	197

As expected, the results indicate a large diversity of operation between the units during the 6 hours of the test, particularly the mining machines. The highest peak reached momentarily was 82.5 kw. The highest 15-minute period which would be the demand of interest for billing purposes was 44 kw. The energy consumption for this section was 0.79 kilowatt-hour per ton. This amount of energy drilled and undercut the coal at four faces and then gathered it by conveyors to the point where the main haulage system received it.

HAULAGE

IN A PREVIOUS SECTION gathering was described as transporting the coal from the faces to a central point where the main haulage system received it. The means of transportation to move the coal from this central point to the tipple is known as the haulage system. Two principal methods of haulage are in widespread use today, namely, rail and conveyor belts. Naturally, for either system power consumption will vary greatly with grades and the length of haulage. Therefore any demand and energy figures will be dependent to a large extent on these factors. However, for most mines the energy consumption for haulage will be between 0.5 and 1.5 kilowatt-hours per ton with differences in grades and distance as previously pointed out resulting in values both less and greater than this.

Tests were made on rail haulage in which two locomotives, one pulling and the other pushing, hauled the same load over different distances and slightly different grades. The locomotives used in the tests were a 13-ton unit rated at 156 horsepower and a 10-ton unit rated at 120 horsepower, or a total connected load of 276 horsepower. The results of the tests are outlined in Table VI.

Table VI. Variation of Power Consumption by Haulage Locomotives With Distance and Grade

Test Number	Distance in Feet	Average† Grade in Per Cent	Average Coal Load in Tons	Momentary Peak Demand in Kilowatts	Average Demand in Kilowatts	Energy Used in Kilowatt-Hours	Energy Use Per Ton Kilowatt-Hour Per Ton
1	3,000	3.83	45	316	211	14.13	0.314
2	5,000	3.20	45	267	196	23.28	0.517

† Against loads

In the second test the distance increased 66.6 per cent and the energy use per ton increased 64.6 per cent to illustrate effectively the direct effect distance has on the energy consumption per ton of coal hauled by rail. However, as the distance increased 66.6 per cent in the second test the average demand decreased 7.1 per cent because of a reduction in grade against which the loads were hauled. In the second test the energy use per ton was 0.517 kilowatt-hour for a haulage distance of 5,000 feet. It readily is apparent that large energy use per ton is experienced with haulage distances of 25,000 feet and over, which are not uncommon.

A large part of the power to drive belt conveyors used for haulage purposes is consumed in overcoming the friction load. One test made on a 36-inch conveyor belt, 2,850 feet long and driven by a 75-horsepower motor, showed a demand of 65 kw or indicated an overloaded condition. To run this same belt empty created a demand of 37.5 kw or 57.7 per cent of the operating demand.

On another test of a 36-inch conveyor, 2,100 feet long, driven also by a 75-horsepower motor, the average demand was only 45.6 kw. This smaller demand reflects the reduced tonnage moved by this belt. The friction load created a 36-kw demand or 79 per cent of the demand required to run coal on the belt. This friction load is unusually high and may have been caused by insufficient lubricant on the rollers.

CONCLUSION

THE CONNECTED HORSEPOWER sometimes is an indication as to what the energy and demand requirements will be for a specific operation such as a haulage locomotive but often the horsepower rating is not reflected as in the case of mining machines. It is vital to bear in mind that each mine has certain conditions which are unique and that the data presented here are based on the average figures for many mines unless otherwise stated. In the cases where specific tests are presented it should not be assumed that these are made necessarily in mines with average conditions. On the other hand, the conditions affecting each test have been made a part of the data for that test.

American Gas and Electric 330-Kv System Equipment

F. A. LANE
MEMBER AIEE

J. H. KINGHORN
MEMBER AIEE

F. M. PORTER
MEMBER AIEE

BUILDING A 330-kv transmission system meant going beyond the existing frontiers and establishing equipment and design principles on an entirely new basis. To go about this job, all available information was gathered together and to supplement this information the tests at the Tidd Plant of The Ohio Power Company were initiated and carried out over a long period of years so that there would be as few questions unsettled as possible when the actual work came to be done.

The corona problem had to be gone into as well as that affecting radio transmission and reception. The large ratings of equipment and line interconnection capacities meant that there would be greater short-circuit duties imposed on breakers than ever before. The larger physical size of the equipment itself presented grave problems of construction and transportation.

Instead of projecting the curves applying to existing voltage transmission systems and the equipment used on them, and extrapolating to get the figures for the new system, it became very necessary for economic reasons to start at the beginning and make sure that everything was done on a sound basis.

Lightning protection has been overhauled thoroughly and transformers particularly have been designed with only enough margin of safety to be co-ordinated with the available lightning protection equipment to give the lowest economic cost which will be consistent with reliability of service.

Shielding of high-voltage equipment was more necessary than ever had been the case before. Studies had to be made and tests had to be made in laboratories to make sure that shielding was adequate and yet was not in excess of actual requirements.

Transmission lines at this voltage require higher structures and necessarily wider rights-of-way than it has been customary to use in the past. Costs go up to astronomical figures if this situation is not watched carefully. Towers have been designed to meet the requirements but no more. A dead-end tower on one of the 330-kv lines is shown on the cover. Insulation has been brought down to as low a value as possible consistent with the best information available from past experience and from test.

Likewise, in designing transmission stations structures had to be a great deal larger than anything heretofore used; yet consistent with the data available these structures have been scaled down to be as small as possible. Insulation has been brought down to values consistent with the values of insulation applied on transformers, circuit breakers, and other equipment so as to get proper co-ordination. Spacing of busses and other live parts has been brought into focus along with these requirements.

Transformers, being the most expensive and most important part of the station equipment, have been designed carefully to give as reliable performance as any of the transformers available at lower voltage. This has meant careful design, experimentation on the part of the manufacturers, and careful attention to detail in building the actual transformers themselves. The impulse level of these transformers has been made as low as is consistent with the voltages which may be imposed upon them by system disturbances and other phenomena. Design of transformers has utilized all of the latest techniques to keep the size as small as possible and permit transportation by existing facilities. By making all 330/132-kv transformers alike and by the system layout used, need for a spare has been avoided in the initial setup.

The oil circuit breakers had to be built to take a duty of 25,000,000 kva, looking into the future only a relatively short number of years. The enormous amounts of power that will be available on a system at this voltage within a comparatively short time make such breakers necessary and we will be faced with the necessity not too far in the future for even larger breakers.

Arresters have been devised using standard equipment but using this equipment in such a way as to give the desired results at the lowest possible cost.

Disconnecting switches, air break switches, bus supports and related equipment all have been co-ordinated to the other factors as logically as possible.

Similar steps have been taken with regard to coupling capacitors and wave traps.

Metering is a problem because of the high voltage and the high cost of potential transformers for such voltages. Therefore various means have been resorted to in order to simplify and reduce the cost of metering by using alternate methods.

The enormous amount of power available and the potential damage to the system from short circuits have made it necessary to review control and protective relaying and to try to get the fastest possible relaying to clear faults and keep damage at a minimum. The large amount of power carried by all elements of the system has made reliability imperative, and all relaying used has been proved by operating experience at lower voltage.

In conclusion, it may be pointed out that everything has been engineered as far as it is humanly possible to do so utilizing the equipment experience of the past and teaming it up with the test data which have been obtained from the Tidd tests and from the laboratories during the last 6 to 8 years.

Digest of paper 54-54, "Equipment for American Gas and Electric 330-Kv System," recommended by the AIEE Committee on Transmission and Distribution and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Winter General Meeting, New York, N. Y., January 18–22, 1954. Scheduled for publication in AIEE *Transactions*, volume 73, 1954.

F. A. Lane, J. H. Kinghorn, and F. M. Porter are with American Gas and Electric Service Corporation, New York, N. Y.

Evaluation of Cable Movement Due to Cyclic Loading

C. A. BAUER
ASSOCIATE MEMBER AIEE

R. J. NEASE

POWER CABLES undergoing daily load cycles are alternately heated and cooled, building up internal stresses which manifest themselves by the longitudinal movement of the cable into and out of adjacent manholes. This movement subjects the cable sheath to cold working ultimately causing it to fail. It is therefore desirable to determine what factors affect the cable movement, how the amount of movement may be calculated, how this movement may be decreased, and to what extent decreased movement is desirable.

To obtain basic field information on cable movement, tests were conducted for a period of 5 years on 500,000-circular-mil 3-conductor 12-kv cable. The test measurements were made on lines having a wide range of lengths, loads, and other field conditions. In every test, recording ammeters and movement recorders were used to get a continuous record for a period of about 4 weeks.

For each length measured a complete record was made of every factor that might affect the results of the test. Evaluating these factors, in the final analysis of the test results, it was found that:

1. Square tile ducts permit more movement than round cement ducts.
2. A clean duct has a lower coefficient of friction than one with silt or other deposits.
3. A rough street surface and heavy traffic causes vibration which reduces the apparent duct friction.
4. Cables manufactured since about 1924 showed greater movement than the earlier cables. Comparing the theoretical equations with the results obtained from field measurements, it was apparent that some adjustments were necessary, as shown in Table I.

Table I. Values of D, K, and E, for Various Conditions

Type of Duct	Traffic Conditions	D	K* Pounds	E Pounds Per Circular-Inch	Time of Cable Manufacture
Square tile	Heavy	0.4	300	11.75×10^6	Since 1924
Square tile	Light or none	0.75	300	11.75×10^6	Since 1924
Square tile	Heavy	0.4	300	7.0×10^6	Before 1924
Square tile	Light or none	0.75	300	7.0×10^6	Before 1924
Round cement	Any location	1.2	300	11.75×10^6	All cables

* $K=1{,}500\ [(8-\log_e(f+1)]/(B+1)$ for known conditions of training.

Using the values of Table I in the following theoretical equations gave results correct to ±20 per cent, with not more than 60 per cent of the total movement at one end of the length.

$$T_c=(WDL+K_1+K_2)/CAE$$

$$M=C^2AE[(T-2K_1/CAE)^2+(T-2K_2/CAE)^2]/4WD;\ 0<T<T_c$$

$$M=LC[T-T_c/2-(K_1+K_2)/2CAE]+(K_1-K_2)^2/2WDAE;\ T>T_c$$

Curves[1, 2] have been presented showing the relationship between life of cable sheath and movement as determined from tests in a dummy manhole. They are for lead sheath[1] and arsenical lead alloy sheath.[2] Taking the curve for lead alloy as an example, its equation is found to be

$$\text{Life}=4.05/S^{(8+1.8)}\ \text{years}$$

$$S=200d(\sqrt{B^2+2fm-m^2}-B)/(B^2+f^2-2d\sqrt{B^2+2fm-m^2})\quad\text{per cent strain}$$

Reducing the width of offset, B, for the cable in the manhole will reduce the cable movement. However, reducing B will increase the maximum strain, S, in the cable sheath and thus reduce the life of the cable. Therefore, both factors must be considered in designing the cable offset.

CONCLUSIONS

1. Cable movement can be calculated if the proper value of duct friction, D, manhole restraint, K, and modulus of elasticity, E, are selected.
2. Traffic vibrations, type of duct, stiffness of cable, and amount of moisture in the soil all must be considered in selecting the constants in the equations.
3. Cable movement is only one of the factors that affect the life of the cable sheath. To get the best over-all manhole design all factors must be evaluated.
4. Heavy restraints at the manhole can cause sheath failure in the duct where it is not detected readily.

NOMENCLATURE

A = Total cross-sectional area of copper in circular inches
B = Width of cable offset in manhole in inches
C = Coefficient of thermal expansion for copper in inches per inch per degree centigrade (16.7×10^{-6} approximately)
d = Outside diameter of cable in inches
D = Coefficient of friction for cable in the duct
E = Young's modulus of elasticity for cable in pounds per circular inch
f = Length of cable offset in manhole in inches
K = Restraining force of the cable in the manhole in pounds
K_1 and K_2 = Restraining forces at opposite ends of cable length
L = Length of duct in inches
M = Total movement in inches for a length of cable
m = Movement of cable at one duct mouth in inches
S = Maximum strain developed in the manhole cable sheath
T = Copper temperature change in degrees centigrade
T_c = The temperature change necessary to produce the maximum change of stress in the cable
W = Weight of cable in pounds per inch

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Digest of paper 54-10, "Evaluation of Cable Movement Due to Cyclic Loading," recommended by the AIEE Committee on Insulated Conductors and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Winter General Meeting, New York, N. Y., January 18–22, 1954. Scheduled for publication in AIEE *Transactions*, volume 73, 1954.

C. A. Bauer and R. J. Nease are with the Commonwealth Edison Company, Chicago, Ill.

Microwave as Applied to Railroad Operation in the Gulf Coast Area

L. R. THOMAS
MEMBER AIEE

This microwave installation was installed not only to supplement existing wire line communication but also to obtain technical data regarding the reliability of a microwave radio relay system under unfavorable atmospheric conditions and terrain. The installation is described and the fading problems and their solution are discussed.

THE SANTA FE railroad has installed a microwave system between Galveston and Beaumont, Tex. The installation is being used to supplement existing wire line communication and to obtain technical information regarding the operation and reliability of a microwave radio relay system in this area. It was felt at the time the decision was made to install the system that, if microwave radio relay could be made to operate reliably in this area, it could be made to provide reliable service on other parts of the railroad where the terrain and atmospheric conditions would be more favorable to its use.

A map of a part of the Santa Fe's facilities in the Gulf area—indicating that prior to the installation of the microwave system it was necessary for telephone and telegraph circuits to be routed from Galveston to Beaumont via Somerville and Silsbee, a distance of 315 miles—is shown in Figure 1. From this point they extend on to Longview, Tex., and Oakdale, La.

The installation of the microwave relay system on a direct route from Galveston to Beaumont, a distance of approximately 70 miles, makes it possible to pick up the circuits from Somerville east at Beaumont and thus release the physical pairs between Galveston and Somerville for other service. This type of installation also reduces the transmission losses experienced in long physical circuits and provides more satisfactory over-all communication from Galveston to the field.

The microwave equipment was supplied by the Philco Company and consists of their Type *CLR-6* terminal and repeaters. There are two terminals and three repeaters in this installation as shown in Figure 2, an over-all diagram of the system showing the antenna heights, distance between repeaters and terminals, and the type of antennas used. The equipment operates in the 6,700-megacycle range with the transmitters providing a power output of approximately 1 watt and receivers adjusted to provide an operating sensitivity of −108 decibels below 1 watt.

The multiplexing equipment used with this installation also was supplied by the Philco Company and is pulse-amplitude-modulated equipment capable of providing a total of 24 telephone channels. In this particular installation equipment to provide only eight telephone channels was used.

The service which is operated over the telephone channels is shown in Figure 3. The first of these is a service channel which is dropped out and inserted at each repeater point to provide communication with field service personnel. This channel also carries the fault tone signals from the terminal at Beaumont and the three repeaters to the control terminal at Galveston. The second channel is used to pick up the dispatcher's telephone circuit which operates between Somerville, Longview, and Beaumont. The third channel is connected to a party-line telephone to Somerville. The fourth channel is connected to a party-line telephone to Longview. The fifth and sixth channels are used as trunk telephones between Galveston and Beaumont, the seventh is idle, and the eighth carries

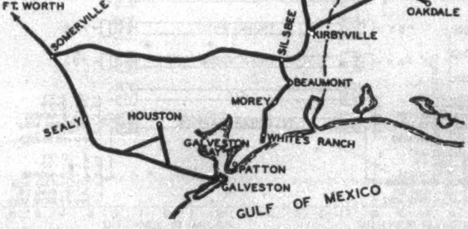

Figure 1. Map showing a portion of the Sante Fe's operation in the Gulf Coast area

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Full text of paper 53-382, "Microwave as Applied to Railroad Operation in the Gulf Coast Area," recommended by the AIEE Radio Communications System Committee and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Fall General Meeting, Kansas City, Mo., November 2–6, 1953. Scheduled for publication in AIEE *Transactions*, volume 72, 1953.

L. R. Thomas is with The Atchison, Topeka and Santa Fe Railway Company, Chicago, Ill.

The author wishes to acknowledge the assistance of R. B. Grantham and W. H. Veerman, assistant engineers, who performed the field work in connection with the Santa Fe microwave installation.

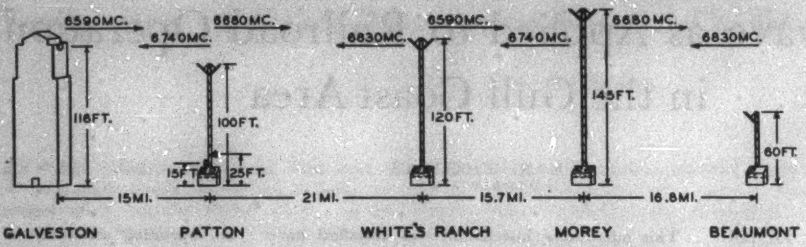

6590MC.
6740MC.
6680MC.
6830MC.
6590MC.
6740MC.
6680MC.
6830MC.
116FT.
100FT.
15FT.
25FT.
120FT.
145FT.
60FT.
15MI.
21MI.
15.7MI.
16.8MI.
GALVESTON
PATTON
WHITE'S RANCH
MOREY
BEAUMONT

Figure 2. Santa Fe microwave system: Galveston – Beaumont

six channels of frequency-modulation telegraph carrier. This channel is capable of carrying up to 14 channels of telegraph carrier if needed.

Ringing on the trunk circuits is accomplished by Western Electric 1,000/20-cycle ring oscillators. Ringing on the dispatcher's and party-line telephones is $3^1/_2$-cycle selector ringing from Beaumont controlled from Galveston over telegraph carrier channels. The ring keys at Galveston operate the send relay on a telegraph carrier channel and the receive relay on the telegraph carrier channel in turn operates the relays of the ring case at Beaumont to provide battery to the physical circuits at that point.

The operators contact the dispatcher by means of his loudspeaker in the normal manner. The party-line telephones on the other hand have 20-cycle ringing from the field by means of hand generators. These operate a 20-cycle relay at Beaumont which actuates the send relay of a telegraph carrier channel and in turn the telegraph carrier receive relay operates a telephone-type relay at Galveston which applies 20 cycles to the private branch exchange drop at that point.

The other telegraph carrier channels are used either for printer circuits or to pick up Morse wires for termination in the Galveston relay office.

The pulse-amplitude-modulated multiplexing equipment has presented a few problems which can be expected with a new type of equipment, but to date these problems have been eliminated in most cases. However, the signal-to-noise ratio which can be obtained from this type of equipment is not as good as that which can be obtained from land line carrier circuits. This is due to a large extent to the signal-to-noise ratio of the microwave system itself and is a problem which no doubt will be taken care of in new equipment.

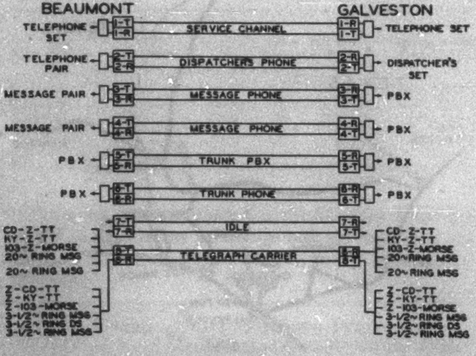

BEAUMONT
GALVESTON
TELEPHONE SET
1-T
1-R
SERVICE CHANNEL
1-R
1-T
TELEPHONE SET
TELEPHONE PAIR
2-T
2-R
DISPATCHER'S PHONE
2-R
2-T
DISPATCHER'S SET
MESSAGE PAIR
3-T
3-R
MESSAGE PHONE
3-R
3-T
PBX
MESSAGE PAIR
4-T
4-R
MESSAGE PHONE
4-R
4-T
PBX
PBX
5-T
5-R
TRUNK PBX
5-R
5-T
PBX
PBX
6-T
6-R
TRUNK PHONE
6-R
6-T
PBX
7-T
7-R
IDLE
7-R
7-T
8-T
8-R
TELEGRAPH CARRIER
8-R
8-T
CD-Z-TT
KY-Z-TT
103-Z-MORSE
20~ RING MSG
20~ RING MSG
Z-CD-TT
Z-KY-TT
Z-103-MORSE
3-1/2~ RING MSG
3-1/2~ RING DS
3-1/2~ RING MSG

Figure 3. Multiplexing circuits on microwave system: Galveston–Beaumont

The trouble experienced with the *CLR-6* microwave equipment has reached the stage where it can be said to be of a more or less minor nature. However, it is only fair to point out that the degree of maintenance required to keep a system of this kind in first class operating condition is rather high. The microwave equipment by its very nature is not a simple device. Therefore, it should be pointed out to those who are contemplating the installation of a microwave system that they should take into consideration the need for more highly trained personnel than is required to maintain a wire line communications plant. Skilled personnel can be obtained or existing employees trained to maintain the equipment satisfactorily.

When this system was installed, it was located in the area where the greatest difficulty could be expected from a standpoint of propagation. Problems were anticipated because of the large bodies of water to be crossed as well as the high moisture content of the air in the Gulf area. Referring to Figure 4, the path from Beaumont to Morey, a distance of 16.8 miles, consists of relatively dry land with large areas covered with trees and buildings. Very little propagation trouble has been experienced in this area. The exception to this consists of the fades which are encountered when there are rapid changes in temperature or in the moisture content of the air. The fades are normally not of sufficient depth to interrupt service. However, outages do occur at infrequent intervals.

The tower at Beaumont is 60 feet high while the one at Morey is 145 feet. In both cases apparently the trees act as zonal screens which tend to reduce the intensity of fades caused by reflection from the surface of the land between these two points.

Referring to Figure 5, the section between Morey and White's Ranch, a distance of 15.7 miles, is relatively dry land and there is little if anything in the path except a few trees and ranch buildings. There are also rice farms in this area which are flooded at certain times of the year. The tower at Morey is 145 feet and the tower at White's Ranch is 120 feet. Some rather severe fades have been

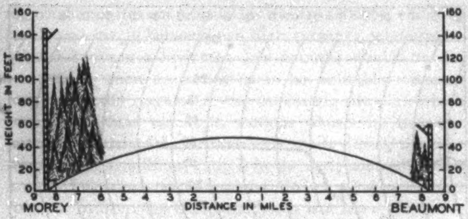


Figure 4. Microwave link: Morey–Beaumont

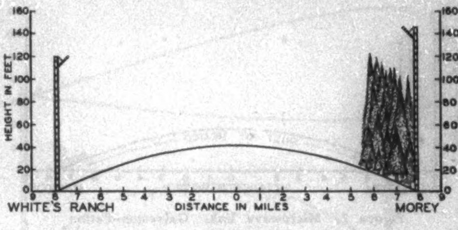


Figure 5. Microwave link: White's Ranch–Morey

experienced in this section. The fades are of the type caused by cancellations due to reflection as well as those caused by moisture fronts such as fog banks.

The section between White's Ranch and Patton, Figure 6, a distance of 21 miles, is over rice farms, salt water swamps, and a portion of Galveston Bay. The tower height at White's Ranch is 120 feet and at Patton 100 feet. However, the reflector on top of the tower at Patton is not being used due to severe fading conditions. The parabola employed in this section is located at a point 25 feet above the base of the tower. Comparative tests made with receivers on both the high and the low antenna at Patton indicated such severe fading conditions with the high antennas that satisfactory service could not be obtained. This fading was apparently due to the changing moisture content of the air over the water and swampy land, as well as some instances of temperature inversion. The characteristics of the fades indicated surface reflection and multipath transmissions resulting in a slight increase in signal, followed by almost a complete cancellation. These fades repeated very rapidly and, in some cases, to the extent that they appeared on the recording voltmeter in a very broad pattern which might be termed "painting." With the low antenna there was very little fading of this nature. However, there are conditions where the signal gradually decreases to a point of outage, staying out for a period of time dependent upon weather conditions, and gradually returning to full strength.

The last section, Figure 7, between Patton and Galveston, a distance of 15 miles over the Gulf of Mexico, has tower heights at Patton of 100 feet and at Galveston 116 feet. In the Patton–Galveston section the same general condition exists as that between Patton and White's Ranch and the reflector on top of the tower at Patton is likewise not being used. The parabola is located at a point 15 feet above the base of the tower.

At the time the original installation was made it was decided to work from parabolas inside of the buildings to passive reflectors on top of towers at all locations, with the exception of Galveston, where the parabola was located on the side of the office building. When severe fading between Galveston and Patton became evident, some action had to be taken in order to obtain satisfactory operation. Several tests were made at Patton with the parabola located at different heights on the tower and recordings were made of the radio-frequency signal strength. Final decision was made to locate the parabola on the tower at a height of 15 feet from the ground working toward Galveston. This establishes a high-low combination of antennas which changes the point of reflection from the surface of the water approximately midway between the two antennas to a point on the surface of the promontory almost at the base of the Patton tower. This arrangement of antennas practically eliminated the fading problems in this section.

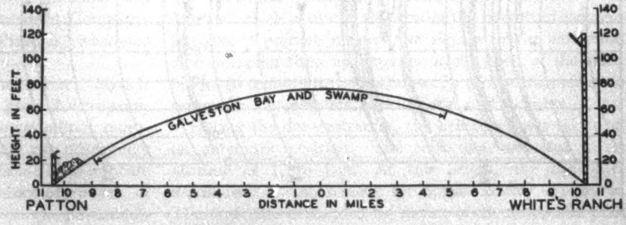


Figure 6. Microwave link: Patton–White's Ranch

When similar difficulty was experienced in the Patton–White's Ranch section, tests were made over long periods of time with different antenna heights in an effort to achieve the same results as were obtained between Galveston and Patton. To date the most satisfactory performance has been achieved with the parabola at Patton mounted on the tower at a point approximately 25 feet above the ground. This location gives very satisfactory propagation results during practically all types of weather conditions except fog. During fog conditions the signal is attenuated to a point where service is disrupted for long periods of time.

Propagation tests covering approximately 2 years indicate that on this system two basic types of fading conditions are generally encountered. One of these consists of a high-maximum low-minimum fade as shown in Figure 8. This type of fading takes place during periods of temperature inversion or changes in humidity which tend to change the index of refraction, thus changing the path length over which the direct and reflected signals pass. Where the length of the direct signal path in

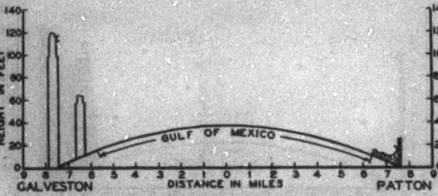
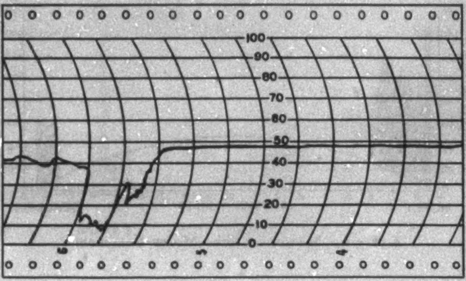


Figure 7. Microwave link: Galveston–Patton



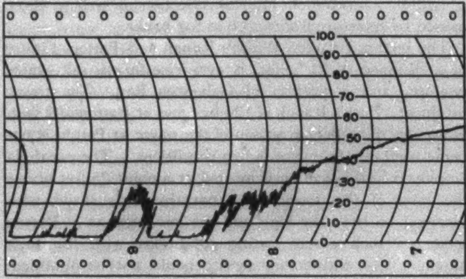


Figure 9. Fade due to high antenna above fog and low antenna in fog

relation to the reflected signal path changes by as much as $^1/_2$ wavelength, the receive signals present at the antenna may change from an in-phase to an out-of-phase condition, thereby increasing and decreasing the resultant signal strength. These conditions exist in the Gulf area when winds come down from the north blowing the moisture, that is normally present, out to sea and dropping the temperature sometimes as much as 20 degrees or more in a matter of a few minutes. They also exist during periods where the ambient temperature and the dew point temperature become the same. Under such conditions condensation takes place and the moisture content of the air increases. This occurs almost every night when there are no storm or fog conditions existing which bring about more violent changes. It was noted with high antennas at both ends of the path that the high-maximum low-minimum type of fades were more frequent and severe in the Patton–White's Ranch and Galveston–Patton sections than those experienced in other sections. As a result of these tests it appears that the use of high antennas on paths over water is impractical. The use of the high-low antenna system, however, greatly reduced this type of difficulty, particularly over the 15-mile path between Galveston and Patton. Apparently this is due to the existing antenna height at Galveston being such that the point of reflection of the interfering signal is transferred from water to land and is very close to the base of the tower at Patton. When a high antenna is worked against a low antenna and the combination of antenna heights and distance separating them is such that the point of reflection of the main beam is at the base of the tower of the low antenna, the difference in path length is reduced to a value where it is evidently not so important a factor.

In the case of the Patton–White's Ranch section, Figure 6, a distance of 21 miles using high-low antennas, the point of reflection is some distance from the base of the tower at Patton where the low antenna is located. However, due to the prevailing moisture content of the air in this area the index of refraction is such that the point of reflection was shifted sufficiently so that the operation was greatly improved as far as high-maximum low-minimum type of fade is concerned.

The second type of basic fade encountered was that brought about by fog. This condition was more prevalent in working a high antenna against a low antenna. During

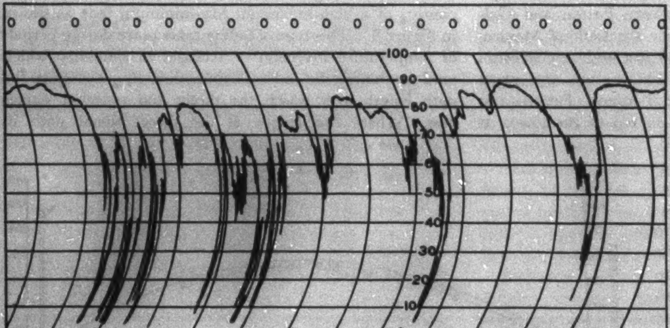


Figure 8. High-maximum low-minimum type of fade

fog conditions it is not unusual for the signals to be relatively stable and strong between two high antennas, while transmission between a high and low antenna would be attenuated to such an extent as to be unusable. Recent tests conducted revealed a very interesting situation which prevails to some extent in sections where the high-low antenna is used. Observations were made during the time when fading conditions existed in the early morning hours and the following was determined: When a fog bank starts to move in from the Gulf, whether it is a heavy dense fog or a light ground fog, it is frequently at a low level and, at a later time, drifts upward. When this condition exists a fade occurs as shown on Figure 9. This is apparently due to the fact that the low antenna is in the fog layer and the high antenna is above this layer. The transmitted signal from the high antenna to the low antenna hits the surface of the fog layer and apparently a greater portion of the signal is reflected. The amount of reflected signal depends largely upon the density of the fog. This is one of the conditions which gives the greatest trouble between Patton and White's Ranch where the high-low antenna system is used.

During such fog conditions the Galveston-Patton section gave a much lesser degree of trouble but nevertheless a definite reduction in signal level was noticed. Due to the shorter distance between Galveston and Patton and the fact that parabolas are used without reflectors, there is less attenuation in this section. Therefore, a greater fading margin is available. Thus it is possible to get a greater degree of signal through the fog in that section and less trouble is experienced.

On the Patton–White's Ranch section using a reflector on one end and with a greater distance involved the path length provides a lower fading margin. Therefore, on occasions this circuit is completely unusable for several hours at a time.

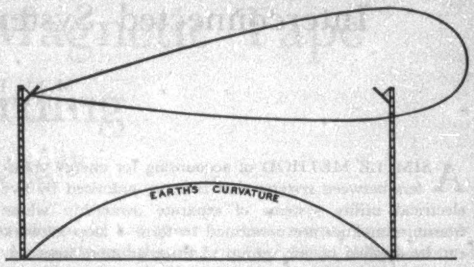


Figure 10. Microwave transmitting beam adjustment

The Patton–White's Ranch section, as well as the White's Ranch–Morey section, also present unusual conditions in case of fog in that their transmission paths are located at an angle to the Gulf. Therefore, when a fog comes in from the Gulf, the front of the fog bank diagonally intersects the transmission path, creating a condition of refraction or reflection that is the same as that produced when one antenna is in the fog belt and the other above. It was noted in both cases that as soon as the fog completely enclosed the antenna on both towers the signals returned to a relatively high level and stable communication was obtained.

In the same recent tests where it was determined what happened during the fog conditions it was found also that over-all stability could be improved if the antennas, Figure 10, were adjusted so that the $^1/_2$-power point on the bottom of the major lobe of the beam were set on the receiving antenna; that is, only the transmitting antennas were adjusted and the receiving antennas were so placed in the beam by this adjustment that they were at a point approximately 2 decibels below the mid-point of the beam. Under conditions of normal weather where the humidity increases slightly between night and day, recordings indicate that there will be a slight increase in level of the signal at night due to the change of index of refraction.

At the present time arrangements are being made to replace the 4-foot parabolas and reflectors with 6-foot units in this system thereby increasing the fading margin. This increase in fading margin should make it possible to obtain reliable communication in all sections of the system.

Automatic Method for Helicopter Control

A completely automatic method for maintaining a helicopter in a hovering position directly above a desired point on the ground and at any desired altitude was demonstrated recently by Hastings Instrument Company, Raydist Navigation Corporation, and Piasecki Helicopter Corporation.

A small transmitter is installed in the helicopter. Signals from two Raydist relay stations on the ground were compared in one phasemeter to indicate longitudinal movements of the helicopter, while signals from two other relay stations were compared in a second phasemeter to indicate the transverse movement. The transducer for each of these error indications was a small low-torque potentiometer attached to the shaft of the respective phasemeters.

As the helicopter, hovering over the reference point, tended to drift to the left or right of the reference point, the transverse phasemeter indicated the movement as rotation which actuated the arm of the potentiometer and introduced positive or negative signals to the autopilot. The autopilot then adjusted the cyclic pitch of the rotor blades to reposition the helicopter in such a manner as to bring the phasemeters back to the null position.

During the demonstration, the helicopter was taken off on automatic position. The craft then ascended to an altitude of 1,100 feet. At this height, the helicopter maintained a stable hover for approximately 7 minutes. The craft also descended by means of the automatic pilot and landed within 1 to 2 feet of the central point.

Interconnected Systems Energy Accounting

M. J. LACOPO
ASSOCIATE MEMBER AIEE

A SIMPLE METHOD of accounting for energy transfers between systems that is being practiced by five electrical utility systems of separate ownership whose transmission lines are connected to form a loop network can be applied by any group of three or more interconnected systems. The method is applicable and advantageous particularly where natural energy flow is permitted through a network and no effort is made to control flows through any interconnection by the use of series capacitors or phase-shifting equipment. It is based upon a comparison of scheduled with actual deliveries and receipts of energy by each system through all of its interconnections with the other systems of the group. Also, it assumes that each system employs an effective means of controlling the net amount of energy delivered or received at all of its interconnections to conform with the predetermined schedules.

Six fundamental defined conditions form the bases of the energy accounting procedure:

1. The scheduled amount of energy to be furnished during each clock-hour period by one system to another is shown in daily schedules prepared by each system.
2. The balance sheet principle of assets and liabilities is used in accounting for scheduled and gross metered energy deliveries.
3. Scheduled energy is considered a liability of the furnishing system and an asset of the receiving system.
4. Actual gross energy is considered an asset of the furnishing system and a liability of the receiving system. The gross kilowatt-hours delivered by each system to the other systems at each interconnection point are recorded for each clock-hour period, and considered as both the amount delivered and received at the point.
5. Each system's kilowatt-hour liabilities and assets are recorded for each clock-hour and any deviation between hourly total liabilities and assets for the particular system is considered as regulation energy received or supplied. If liabilities exceed assets for an hour, the excess is debited against the system in a general clearing account called the regulation account. If assets exceed liabilities, the excess is credited to the system in the account.
6. The central clearing agent, one member of the interconnected group, maintains hourly records to determine each system's debits and credits.

Example of Accounting. It is assumed that kilowatt-hour deliveries between three systems forming a loop are as follows:

Scheduled: *A* to *B* 20,000, *B* to *C* 5,000, *A* to and from *C* 0.
Actual: *A* to *B* 13,000, *A* to *C* 8,000, *C* to *B* 4,000.

Balance sheet and regulation account figures resulting from the foregoing conditions are shown in Table I. It will be noted that the algebraic sum of the total energy delivered and received that is placed in the regulation account is zero; a result which provides a helpful check of hourly records covering deliveries at many interconnection points. In actual practice the regulation debits or credits to each system are not recorded as indicated in the table under assets or liabilities. Actual records show up to and including the subtotals and both items of the regulation account. The differences between the subtotals are recorded either as credit or debit, as the case may be, in the regulation account.

Table I. Kilowatt-Hour Balance Sheet

	Company A		Company B		Company C	
	Assets	Liabil.	Assets	Liabil.	Assets	Liabil.
Scheduled	0	20,000	20,000	5,000	5,000	0
Actual	21,000	0	0	17,000	4,000	8,000
Subtotal	21,000	20,000	20,000	22,000	9,000	8,000
Regulation dr/cr		1,000	2,000			1,000
Total	21,000	21,000	22,000	22,000	9,000	9,000

Regulation Account

	A	B	C	Total
Regulation energy delivered	1,000		1,000	2,000
Regulation energy received		2,000		2,000

Settlement for regulation energy is practically an hour-to-hour responsibility. If a system incurs a debit during an hour, it has the responsibility during the following hour to establish a like credit, except during the last peak hour and off-peak hour each day. A peak debit can be offset only by an equal peak credit, and an off-peak debit only by an equal off-peak credit. Electrical losses that are associated with transfers are taken into account. The amount of loss is treated as a scheduled quantity and deliveries and receipts are made accordingly. For example, if *A* has scheduled a supply of energy to *C* and this results in *B* receiving 12,000 kilowatt-hours from *A* and delivering 10,000 kilowatt-hours to *C* simultaneously; 2,000 kilowatt-hours would be recorded as a scheduled asset by *B* and a liability by *A*.

Preparation of Schedules. Latitude is allowed on the minimum time required for prior notices to permit establishing schedules by load dispatchers. Under favorable circumstances schedule changes may become effective within 1 hour of prior notice. Equally liberal is the time permitted to carry out a schedule change. Certain conditions permit a rate of change as great as 10,000 kw per minute; in other cases the limit of the rate of change is 3,000 kw per minute.

Digest of paper 53-383, "Interconnected Systems Energy Accounting Procedure and Related Operating Practices," recommended by the AIEE Committee on System Engineering and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Fall General Meeting, Kansas City, Mo., November 2–6, 1953. Scheduled for publication in AIEE *Transactions*, volume 72, 1953.

M. J. Lacopo is with American Gas and Electric Service Corporation, New York, N. Y.

Synchronized Magnetic Tape Recording

R. H. RANGER
FELLOW AIEE

Magnetic recording has shown it has great possibilities in quality and economy and the use of this facility for the sound with motion pictures is attractive. The use of 1/4-inch tape without sprocket holes is more flexible than film because of its thinness, it takes up less space, and it gives excellent quality of reproduction. Synchronization between picture and sound on the tape—an important problem—has been accomplished.

MOTION PICTURES obviously have required synchronized sound to match picture and words in all released prints. Perforated film has been the usual answer to this requirement ever since sound was added on film, but now that magnetic recording has shown such tremendous opportunities in quality and economy the use of this facility for sound for motion pictures is immediately attractive. One answer has been the use of normal photographic film stock, coated, however, with iron oxide instead of the usual silver emulsions. And again perforations accomplished the lock-in. But quarter-inch tape without sprocket holes is so much more flexible because of its thinness, it takes up so much less space, and it gives top quality with so little effort that its use certainly would be ideal if the synchronism might be accomplished also.

CONTROL TRACK RECORDING

INSTEAD OF relying on mechanical lock-in to accomplish synchronism with 1/4-inch tape, electronic lock-in has been a most satisfactory answer. Among the several methods proposed, the method here described consists in recording on the same 1/4-inch tape not only the normal longitudinally magnetized audio-frequency record but also a control track consisting of a transverse magnetization from the 60-cycle power driving both the tape machine and the camera at the time of the picture shooting. This makes for maximum simplicity in recording, gives two channels, one for the usual sound in the normal manner, and the other for the control track with no interference by the control track on the audio channel.

The object of having the control track is to provide means on playback for automatically controlling the speed of the tape machine so that the audio track will remain in synchronism with the film, regardless of the absolute speed of the film.

It is easy enough to record a transverse flux in step with the 60-cycle power using a head turned at right angles to the normal audio heads This means that the control recording head shown at *A* in Figure 1 is turned at right angles to the direction of the motion of the tape and normally is placed to record directly in the center of this tape. Gap width in most magnetic heads is of an extreme fineness—of the order of 0.5 mil. The first answer to recording the control track was to use this fine gap exactly in line with the tape movement and register a 60-cycle track in the center of the tape. This required, however, a relatively short gap in the direction of motion of the tape such that the recording of the 60 cycles, where the tape first contacted the gap in the head, would not be cancelled out when this same portion of the tape hit the trailing end of the gap. To avoid this and also to make the alignment of the tape with the head much less critical, the gap *T* is tilted at an angle of 6 degrees as shown on *A* in Figure 1. This means that as the tape moves to the right and a small voltage from the 60 cycles is applied to the coils of head *A*, the various phases of the recording cycle are put down in shingle fashion over each other along the tape as indicated at *S*. This tilt as selected is downwards from left to right looking at the front of the head with the tape passing over it from left to right. It could have been exactly the other way just as well. In fact, it is possible to place two independent control tracks on a single tape, one tilting downwards and the other upwards.

In order to prevent this shingled magnetic recording track from affecting the audio track, the length of the tilted gap is most important. The primary standard tape speed for professional work is 15 inches per second, with $7^{1}/_{2}$ inches per second as the secondary standard. At 15 inches per second the tape moves forward 1/4 inch for every 1/60 second representing 1 cycle of a 60-cycle power source. It is seen that at any instant a vertical gap would cut across a succession of these shingled phases. The resolution of the flux F_0 for the 360-degree point is shown at the left of the gap *V* in *B* of Figure 1, with F_2 the flux which alone would affect the audio gap *V*. But the summation of all these small F_2 fluxes from zero to 360 degrees would add vectorially to zero to give no effect magnetically on gap *B* provided this gap is cutting only from zero to 360 degrees of the shingled fluxes. This will happen if the effective length of the recording gap in the direction of F_2 along the tape is 1/4 inch.

Complete text of paper 53-300, "Synchronized Magnetic Tape Recording," recommended by the AIEE Committee on Television and Aural Broadcasting Systems and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Summer General Meeting, Atlantic City, N. J., June 15–19, 1953. Scheduled for publication in AIEE *Transactions*, volume 72, 1953.

R. H. Ranger is president of Rangertone, Inc., Newark, N. J.

The author acknowledges the collaboration of P. M. Brubaker, chief engineer, Rangertone, Inc.

To be sure that the effective magnetic length of the gap is 1/4 inch, the matter was checked very completely by using a fixed gap length which was accurately measured physically at 1/4 inch. Then with the 60-cycle control recording current held constant, the tape speed was varied and the pickup in the audio head *B* was measured. Figure 2 shows the resultant curve made by calculating equivalent gaps based on speed variations. A definite minimum was established in this crosstalk in the audio-frequency channel which was down at least 10 decibels from what the normal 15-inch speed would have given without this accurate speed adjustment. The speed turned out to be 15.45 inches per second for this minimum reading. This showed that with the physical length of the gap of 0.250 inch the actual recording was spreading out to be $\frac{15.45}{60}=0.2575$ inch. By interpolating from this it was determined that the actual gap length along the tape should be 0.242 inch instead of 0.250 inch for minimum crosstalk at the regular 15-inch-per-second speed.

With an impedance of approximately 200 ohms at 60 cycles on the record head, 0.25 volt gives an ample record of the 60-cycle pulse on the tape. Directly off the control playback head 150 microvolts are easily obtained. On the audio pickup head the crosstalk from this control track will be of the order of 53 decibels down from the normal audio signal.

The synchronizing playback control head is made very similarly to the synchronizing record head, except that the angle is increased to 10 degrees which merely means that the tape can have greater excursion up and down. The gap width for control recording is 2 mils and for playback is 9 mils.

TAPE PATH

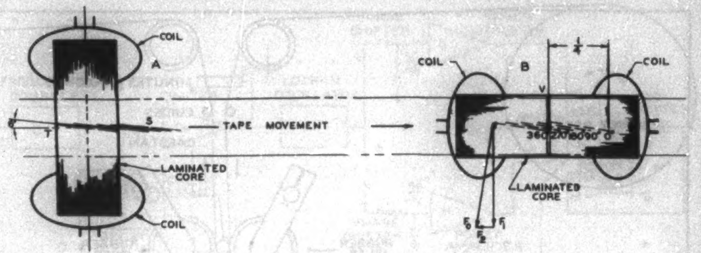
In order to provide a very smooth controllable tape path which will have a minimum of flutter, the tight loop drive has been initiated on 1/4-inch tape on this equipment as shown in Figure 3 for the top plate. The tight loop is the small section in the center from the drive capstan in the center down to the flywheel at the bottom. This tight loop has been used for motion picture film for several years except that with tape there can be no sprocket wheels to maintain the loop. The rubber idlers hold the tape in contact with the capstan on each side, and the rotation of this capstan communicates itself to the tape and the tight loop down to the flywheel and back. It would seem that the amount of tape going in would be exactly equal to that going out so that there would be no tension on tape in the tight loop. It is surprising to see, however, that the tape in the tight loop actually tightens up, even with only the single diameter on the capstan. This is because there is an actual tension balance in the tape going in and going out, determined practically entirely by the tension on the tape accomplished by the drag of the supply reel in the upper left of the top plate. This tension is accomplished by applying the right amount of direct current on the induction motor connected to the supply reel. This makes the tape tension at the capstan where it enters on the left greater than that on the right where the tape leaves. This tension means that the tape actually will be stretched slightly more at entering than it is on leaving. Therefore, it takes more rotation of the capstan to put tape into the loop than it takes to pull it out. The net result is that the amount of tape in the loop decreases up to the time when a balance point is reached when the tension on the inside of the loop equals that of the tape entering from the supply reel. After this point is reached the tape tensions remain in balance, and the loop stays tight.

For effective operation, the heads are put in the following sequence: first comes the synchronous playback head, followed by the erase head. The reason for putting the synchronous playback head first is so that it will pick up a synchronizing signal if one already has been made on the tape. This will hold the tape at exactly the speed in which the original synchronous recording was made. If a new recording is to be made, the tape then passes on by the erase head. The erase head has a transverse wide gap supplied from a high-frequency source; 80,000 cycles is currently used. This completely erases audio and synchronizing signals from a tape that is already recorded. The tape then passes on to the audio record head, which has a very narrow gap of the order of 0.5 mil in thickness, and then the tape passes around the flywheel.

The tape then passes on to the audio play head, which again has a narrow gap, and finally leaves the tight loop by passing the synchronous record head which gives the shingled recording previously described from low-voltage 60-cycle power. This new synchronous recording will match the spacing of the original recording, because the latter holds the tape speed during this operation.

SPEED CONTROL

Now to control the tape speed, it is possible to use a synchronous motor driving the capstan and change the frequency of the power driving the synchronous motor. But this takes considerable power which is hard to generate from tubes, and a far more practical answer has been set up on this equipment as shown diagrammatically in Figure 4. The synchronous motor is connected directly to the normal 60-cycle power. The capstan is driven from the synchronous motor by means of a conical spindle on the motor and a conical rubber drive wheel on the capstan shaft. In this way the actual rotational speed of the capstan is determined by the effective diameters of the motor conical spindle and the rubber drive where the two contact. Now, if the whole synchronous motor is moved up and down it is seen that the effective diameter of the conical spindle where it contacts the rubber drive will vary, and as a result the speed ratio between the capstan and the synchronous motor will change. A ±3-per-cent speed change from the 15-inch normal tape speed may be accomplished with the equipment as set up. The actual movement of the synchronous motor up and down is accomplished through a clockwork gear reduction from a very small a-c induction control motor. Or it may be accomplished manually as shown by the speed control dial on Figure 3 in the left center. A spring is used to counterbalance the weight of the synchronous motor.



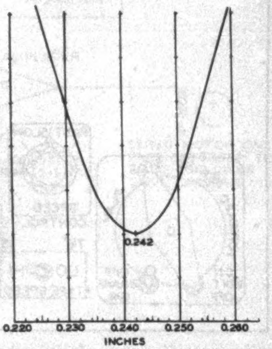


Figure 1 (above). Synchronous recording on magnetic tape. The control recording head at A applies a small 60-cycle voltage at an angle of 6 degrees and the audio is recorded by the head at B. Figure 2 (right). Graph showing crosstalk as a function of recording gap length

A large operating switch is in the lower left-hand corner of the top plate, Figure 3, with positions as shown. In the position shown the contol knob is at stop. Twisting it to the right puts the machine in play. In this position the tape will play back a previously recorded signal and the speed of playback will be determined by the control signal. While the machine is in the play position, the edit on-or-off switch may be flipped into the slot in the cam attached to the control knob, which then brings into action the edit switch on the lower right of the top plate. This edit switch has three positions, center for stop, right for forward, and reverse for backward. With this switch, the tape moves at normal speed forward and back which facilitates picking out spots on the tape, because their pitch will be normal even though the tape may be going backwards. A separate pushbutton for recording (not shown) is then necessarily pushed to do recording, and a red light above the erase head shows that it is in operation, and a green light above the synchronous record head shows that it is putting the control track down on the tape.

For rewind, to take the tape back from the takeup reel on the right to the supply reel on the left, the control knob is turned to the position at the left of stop and then the knob on the far right lower part of the top plate may be used to change the speed of the rewind, so that selections may be approached slowly when necessary. Then on turning the control knob to the extreme left the tape will go forward under this same right-hand control knob, either slow or fast. The heads are assembled on swivel mounts, so that on rewind the mounts are turned back out of contact with the tape so that the tape does not wear them out unduly. The rubber idlers in the center of the top plate are solenoid driven and are in position only when the control knob goes to play. This again relieves the tape tension on the idlers, capstan, and heads on rewind.

SYNCHRONOUS PLAYBACK

Finally comes the matter of picking the control signal off a recorded tape and making it hold the tape absolutely in step with the film even though the tape may be stretched because of humidity or temperature changes. This is accomplished by changing the capstan speed as previously described. The equipment that does it automatically is a synchronizer of special design shown in Figure 5.

Starting with the synchronous playback head *A* in the upper left, the signal, which should be 60 cycles from the tape, has a value of anything from 150 to 1,000 microvolts which is built up in amplifier *B* to 5 volts. It then is doubled in frequency at *C*. One of the purposes of doubling it is to minimize splicing junction errors. Obviously if two sections of tape are joined together, the chances that the 60-cycle recording would be joined absolutely accurately would be most problematical. However, if the frequency is doubled, the consequent out-of-phase error which may come from splicing will be just half as serious, because with the frequency doubled the effect is the same whether a plus or a minus half of a 60-cycle pulse reaches this point of the circuit. The maximum error in splicing thus will be half a cycle or 1/120 second which is only 1/5 of a motion-picture frame. Whenever a signal from the tape reaches this point, it releases a relay *E*, which turns on a green light indicating that the synchronizing signal is present. This also puts the entire control operation into action. Obviously there should be only corrective action when the synchronizing signal is present and a purposeful correction is indicated. The 120 cycles as doubled at *C* then goes on to an amplifier-limiter at *D*, which establishes a fixed level of 20 volts up to this point whenever the synchronizing signal is present. An oscillator is driven by this 120-cycle signal at *F*. This oscillator is nominally at 60 cycles and the 120-cycle input locks it in very nicely. It is again advantageous to have 120 cycles for this junction because waveform variations in these 120 cycles have much less effect on the waveform of the oscillator at 60 cycles than they would if they both were at 60 cycles.

After oscillator *F* the circuit is split with a phase shifter; the top half advances the signal 45 degrees and the bottom retards it 45 degrees by the appropriate capacitor-resistance combination. Power amplifiers *G* and *H* follow these phase shifts, and these in turn activate the 90-degree separated coils of the stator of the resolver at *K*. The rotor of this resolver in turn is supplied by straight 60-cycle power, with again a phase differentiation accomplished by a capaci-

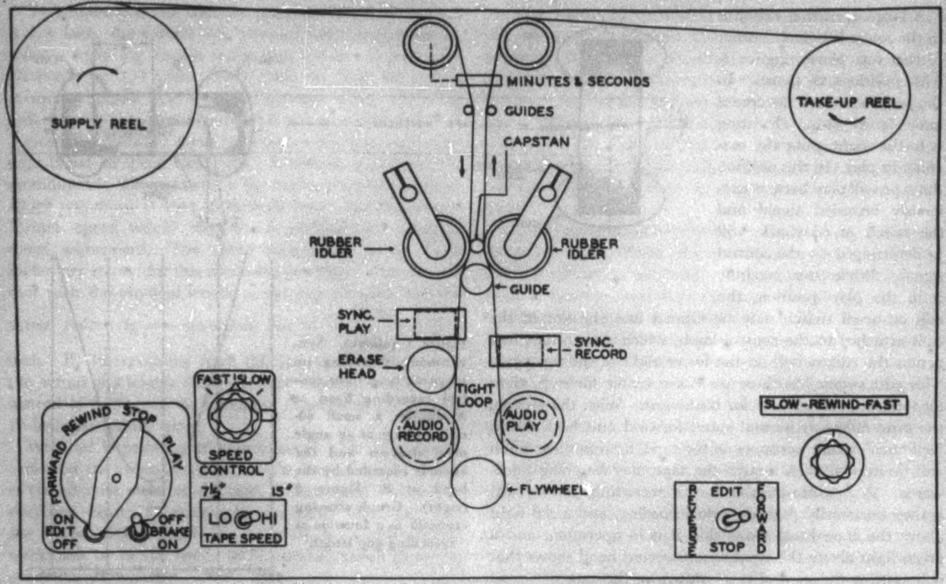

SUPPLY REEL
MINUTES & SECONDS
GUIDES
CAPSTAN
TAKE-UP REEL
RUBBER IDLER
RUBBER IDLER
GUIDE
SYNC. PLAY
SYNC. RECORD
ERASE HEAD
TIGHT LOOP
AUDIO RECORD
AUDIO PLAY
FLYWHEEL
FAST SLOW
SPEED CONTROL
7½"
15"
LO HI
TAPE SPEED
FORWARD
REWIND
STOP
PLAY
ON EDIT OFF
OFF BRAKE ON
SLOW-REWIND-FAST
REVERSE
EDIT
STOP
FORWARD

Figure 3. The path followed by the tape on the top plate

tor in coil *L*, while coil *M* is fed directly. These phase-shifting networks on both stator and rotor make the resolver have two rotating fields. If these fields are identical, meaning that the 60 cycles as picked up from the head is exactly in step with the 60-cycle power then being used, there will be no resultant motion of the resolver. However, if the frequency of the tape pickup is lower than that of the 60-cycle reference, the rotor will move in such a direction as to compensate for this discrepancy, meaning that the rotor actually will move to place its coils in line with the more slowly energized coils of the stator. Conversely, if the synchronizing signal from the playback is ahead, the resolver will move in the other direction.

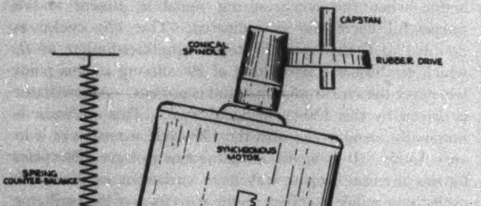

CAPSTAN
CONICAL SPINDLE
RUBBER DRIVE
SYNCHRONOUS MOTOR
SPRING COUNTER-BALANCE
CONTROL MOTOR

Figure 4. The variable-speed drive

The motion of this resolver *K* is transmitted mechanically through a very high gear reduction to a potentiometer at *R*. The purpose of this potentiometer is to apply normal 60-cycle power to what amounts to a bridge leading to amplifier *S*. When potentiometer *R* is in its center position, there will be no resultant voltage from the transformer *N* through the high-pass filter *Z* to amplifier *S*. If the mechanical motion of the resolver calls for the potentiometer *R* to move upward, the 60-cycle balance will be upset, and one phase of the 60 cycles will carry on through to amplifier *S*. This amplifier in turn drives a very small induction motor *T* which through a very high gear ratio moves the main synchronous drive motor of Figure 4 up and down to control the speed of the capstan on the top plate. If arm *R* moves down, the opposite phase of the 60 cycles will be applied to motor *T* and this then will rotate the motor in the other direction. It is to be noted that the 60-cycle voltage is proportional to the displacement of *R*, and this in turn regulates the speed of the correction motor *T*.

If this were all there was to the control, the whole system would hunt forward and back about the neutral position. In order to avoid this hunting a velocity error signal must be introduced, which is proportional to the rate at which the potentiometer moves. For this purpose, potentiometer *R* picks up a direct voltage from the plate power line to ground. When the potentiometer arm *R* is moving, the d-c charge on capacitor *Y* is changing and causing transient current pulses which are proportional to the rate of change to flow through the germanium bridge *W*. This bridge *W*

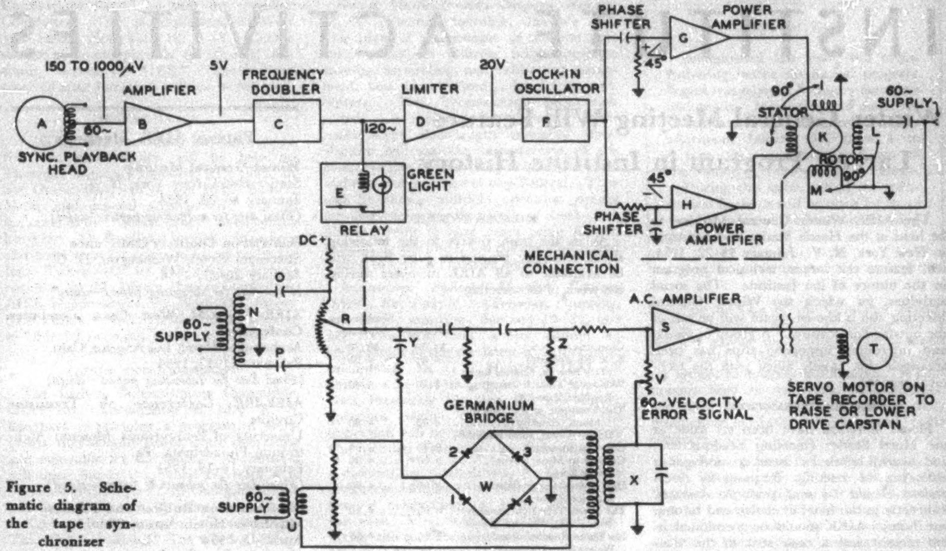


Figure 5. Schematic diagram of the tape synchronizer

also is fed by 60-cycle power from transformer *U* which is balanced through the bridge to ground, so normally there will be no 60-cycle output in transformer *X* on the right. Any output of transformer *X* carries up to the point of amplifier *S*, which is carrying the normal a-c signal from potentiometer arm *R* into the small induction motor *T* on the extreme right. Now, however, if a pulse comes through capacitor *Y* by the movement of arm *R*, this pulse will carry into the bridge *W*. If this pulse is negative, it will carry through the bottom half *1* and *4* of the bridge *W;* if it is positive, through the top half *2* and *3*. In so doing, it will upset the normal balance of the 60 cycles coming into the bridge *W* from transformer *U*. If the pulse is positive, it will go down arm *1* and up arm *4* of the bridge *W*. In so doing it will add to the plus half cycles coming from the 60-cycle transformer through arm *1* and actually oppose the other half cycles which carry up from ground through arm *3*. The net result is to give stronger half-cycle pulses in the lower half of the primary of transformer *X* than in the upper half. This then will give 60-cycle pulses in the output of transformer *X* which are led up through a variable resistance *V* to phase or not with the 60-cycle power coming through the 60-cycle filter as determined by the position of *R*. The output of transformer *X* is tuned to 60 cycles with a capacitor. The net result of these actions is to give additional 60-cycle power into the amplifier *S* in accordance with the operation of potentiometer *R*. A linear alternating current either in phase or out of phase will be combined with the alternating current coming directly from the potentiometer *R* when the latter moves. In other words, when the potentiometer has moved in one direction and then begins to move back, the back movement will give alternating current from bridge *W* which will be out of phase with that originally coming from the unbalanced condition set up by potentiometer *R*, and the transformer *N*. This decreases the a-c power on the motor *T* when the corrections have started to take effect.

This is, of course, the well-known setup to prevent hunting by making a velocity correction which precedes the position correction coming directly from potentiometer *R*. By changing the value of the resistor *V* the amount of this control may be adjusted to make hunting a minimum.

The gear reduction on the motor *T* to move the main drive motor up and down is made so high that the tape correction speed shall be relatively slow. It takes something like 3 seconds to accomplish 1/24-second actual change in the tape movement which would correspond to one frame of a motion picture running at 24 frames a second. This change is so slow that it never affects music; correction may be applied constantly and strict synchronism with the picture will result. Actually in practice the normal movement of the correction when once conditions have stabilized is of the order of about 1/10 of a frame plus or minus, and this means again a very slow rate.

CONCLUSION

With these facilities, the top quality characteristics of 1/4-inch flexible tape are put at the disposal of motion-picture producers to come up with synchronous sound absolutely in step with the film. Joining tape lengths together does not interfere with the normal correction process. So an over-all inexpensive effective recording medium has been established which has forwarded the motion-picture art, and is being particularly applied to motion pictures for television, as well as educational, religious, and industrial films.

INSTITUTE ACTIVITIES

Winter General Meeting Will Feature Largest Program in Institute History

The AIEE Winter General Meeting to be held at the Hotels Statler and McAlpin in New York, N. Y., January 18–22, 1954, will feature the largest technical program in the history of the Institute. The social activities, for which the Winter General Meeting also is known, again will be one of the outstanding features. A group of varied and interesting inspection trips has been arranged also, closely allied with the technical sessions.

HOTEL RESERVATIONS

Blocks of rooms have been set aside at the Hotel Statler (meeting headquarters) and nearby hotels for members and guests attending the meeting. Requests for reservations should be sent prior to January 8 directly to the hotel of choice and to only one hotel. AIEE should be mentioned in the request and a copy sent to the vice-chairman of the Hotel Accommodations Committee, D. V. Buchanan, Room AU16, Consolidated Edison Company of New York, Inc., 4 Irving Place, New York 3, N. Y. A second and third choice should be noted on this copy.

Due to the current accommodations situation in New York hotels, reservations for arrival on Sunday, January 17, are suggested. If the accommodations at the hotel requested are not available, the Hotel Accommodations Committee will transfer the request to one of the other hotels on the list.

Hotel rooms have been reserved at the following:

Hotel Statler (meeting headquarters), 7th Avenue, 32d to 33d Streets

Single room with bath	$ 6.00 to $11.00
Double room, double bed	8.00 to 14.00
Double room, twin beds	9.00 to 16.00
Studio type	15.00 to 18.00
Parlor suites	25.00 to 27.00

Hotel Governor Clinton, 7th Avenue at 31st Street

Single room with bath	$ 6.00 to $ 8.00
Double room, double bed	8.50 to 10.00
Double room, twin beds	10.00 to 13.00

Hotel McAlpin, Broadway and 34th Street

Single room with bath	$ 4.50 to $ 9.25
Double room, double bed	7.00 to 13.50
Double room, twin beds	8.50 to 13.50

New Yorker Hotel, 34th Street and 8th Avenue

Single room, tub and shower	$ 6.00 to $10.00
Double room, double bed	9.00 to 14.00
Double room, twin beds	10.50 to 16.00

Hotel Martinique, Broadway and 32d Street

Single room with bath	$ 4.50 to $ 7.00
Double room, double bed	8.00 to 11.00
Double room, twin beds	9.00 to 12.00

Hotel Commodore, 42d Street at Lexington Avenue

Single room with bath	$ 6.00 to $10.00
Double room, double bed	9.50 to 12.50
Double room, twin beds	11.00 to 15.00

Hotel Roosevelt, Madison Avenue at 45th Street

Single room with bath	$ 6.50 to $14.00
Double room, double bed	11.50 to 17.50
Double room, twin beds	13.50 to 20.00

Rates are subject to 5 per cent New York City hotel room tax.

THEATER TICKETS

As in the past, tickets to the following shows currently playing in New York will be available to all AIEE members during the week of the meeting.

	Evenings	Wednesday Matinee
Cinerama	$4.00	$2.70
Kind Sir (comedy) Mary Martin, Charles Boyer	6.00	6.00
Wonderful Town (musical) Rosalind Russell	8.40	5.40
The Teahouse of the August Moon (comedy) David Wayne, John Forsythe	6.00	4.80
Can-Can (musical)	8.40	6.00
Comedy in Music (revue) Victor Borge	6.00*	4.80
Dial M for Murder (drama) Maurice Evans	6.00*	4.80
The Seven Year Itch (comedy) Tom Ewell, Vanessa Brown	6.00*	4.80
My Three Angels (comedy) Walter Slezak	6.00	4.80
Picnic (drama, Pulitzer Prize) Ralph Meeker	6.00*	4.80**
Rodgers and Hammerstein musicals		
Me and Juliet Isabel Bigley Joan McCracken	8.40	5.40
The King and I Yul Brynner	8.40	5.40
South Pacific Martha Wright George Britton	6.00	4.20

* $7.20 for Friday or Saturday.

** Thursday matinee.

All prices shown are brokers' prices.

Checks should be made payable to: "Theater Ticket Committee, AIEE." Requests also should include first and second choice of both name and date of show, and should be sent to: Theater Ticket Committee, AIEE, c/o S. Friend, Jr., Anaconda Wire and Cable Company, 25 Broadway, New York 6, N. Y.

Preference will be given in order of receipt to requests for seats in blocks of pairs and the committee reserves the right to reduce requests to sell-out shows to two tickets.

All ticket requests will be acknowledged promptly and refund will be made of any money due in excess of the price of tickets purchased.

Please do not include with theater ticket applications payment for any meeting fee or other item for which remittance should be made directly to Institute headquarters.

Tickets to available radio broadcasts and television shows also will be provided at the time of registration for the meeting.

SMOKER

The Smoker Committee, under the chairmanship of C. F. Bolles, announces that the smoker will be held on Tuesday evening, January 19, at the Hotel Commodore. Tickets are $10 each and include gratuities.

Future AIEE Meetings

Winter General Meeting
Statler Hotel, New York, N. Y.
January 18–22, 1954
(*Final date for submitting papers—closed*)

Scintillation Counters Conference
Shoreham Hotel, Washington, D. C.
January 26–27, 1954
(*Final date for submitting papers—closed*)

AIEE-IRE-ACM West Coast Computer Conference
Ambassador Hotel, Los Angeles, Calif.
February 11–12, 1954
(*Final date for submitting papers—closed*)

AIEE-IRE Conference on Transistor Circuits
University of Pennsylvania Museum Auditorium, Philadelphia, Pa.
February 18–19, 1954
(*Final date for submitting papers—closed*)

Conference on Rubber and Plastics
Mayflower Hotel, Akron, Ohio
April 5–6, 1954
(*Final date for submitting papers—January 7*)

Southern Textile Conference
A. French Textile School of Georgia Institute of Technology, Atlanta, Ga.
April 15–16, 1954
(*Final date for submitting papers—January 15*)

Conference on Feedback Control
Claridge Hotel, Atlantic City, N. J.
April 21–23, 1954
(*Final date for submitting papers—January 25*)

AIEE-IRE-RETMA-WCEMA Electronic Components Conference
Washington, D. C.
May 4–6, 1954
(*Final date for submitting papers—February 4*)

North Eastern District Meeting
Schenectady, N. Y.
May 5–7, 1954
(*Final date for submitting papers—February 4*)

Appliance Technical Conference
Morrison Hotel, Chicago, Ill.
May 17–19, 1954
(*Final date for submitting papers—February 19*)

Electric Welding Conference
Milwaukee, Wis.
May 19–21, 1954
(*Final date for submitting papers—February 19*)

AIEE-IAS-IRE-ISA Conference on Telemetering
Morrison Hotel, Chicago, Ill.
May 24–26, 1954
(*Final date for submitting papers—February 25*)

Summer and Pacific General Meeting
Biltmore Hotel, Los Angeles, Calif.
June 21–25, 1954
(*Final date for submitting papers—March 23*)

Machine Tool Conference
Detroit, Mich.
November 8–10, 1954
(*Final date for submitting papers—August 8*)

Reservations should be sent to: Smoker Committee, AIEE Headquarters, 33 West 39th Street, New York 18, N. Y. Checks should be made payable to "Special Account, Secretary, AIEE." Reservations received after January 5 will not be honored.

DINNER-DANCE

J. G. Derse, chairman, has announced that the dinner-dance will be held on Thursday evening, January 21, 1954, in the Grand Ballroom of the Hotel Statler. Music and general arrangements will be the same as those which proved so enjoyable last year. Dress will be formal. Plan now and write soon for reservations at tables for ten. Tickets will be $12 each. Address requests to the Dinner-Dance Committee, AIEE Headquarters, 33 West 39th Street, New York 18, N. Y. Make checks payable to "Special Account, Secretary, AIEE."

LADIES' ENTERTAINMENT

The Ladies' Entertainment Committee, under the chairmanship of Mrs. E. S. Banghart, is planning a program of social events that should prove both interesting and enjoyable for the ladies. Registration will open Sunday, January 17, from 4 to 6 o'clock in the foyer of the Georgian Room, and from 9 a.m. on Monday, January 18, in Ladies Headquarters on the mezzanine. The "Get-Acquainted" Tea will be held on Monday afternoon. Among other events, such as a trip to the United Nations, a luncheon and fashion show at the Waldorf-Astoria, and sightseeing trips, there will be a dinner with entertainment on Tuesday evening (the night of the men's smoker) in the Penn Top.

Ladies are urged to send reservations in advance to Ladies' Entertainment Committee, AIEE, 33 West 39th Street, New York 18, N. Y.

INSPECTION TRIPS

A program of inspection trips of both technical and general interest has been arranged for those attending the Winter General Meeting. Since the number of people who may be accommodated on all of these trips is limited, members who are interested are urged to make arrangements and obtain full details at the Inspection Trips Desk immediately after registering at meeting headquarters. Advance registration by mail for trips cannot be accepted. On some of the trips, proof of United States citizenship will be required, and members should be prepared to comply with such security regulations as may be in force at the time of the trip.

Radio City Music Hall, New York, N. Y. (Tuesday morning, January 19). This traditional trip again has been scheduled, this year marking its fifth anniversary. Spectacular stage shows with colorful and unique lighting effects have made the Music Hall world-famous. Members will see the back-stage facilities as well as the revolving sectionalized stage, elevator-type orchestra platform, motorized curtains, and the multitudinous electric and mechanical controls required to accomplish the special lighting effects. The magnitude of these operations is evident from the fact that the connected load totals 5,500 horsepower in motors and 3,500 kw in lighting.

Federal Electric Products Company, Newark, N. J. (Tuesday morning, January 19). This plant is an example of modern production methods utilizing fully automatic forming, assembling, and calibrating equipment, and decentralized independent work centers. This decentralized production system has replaced the standard 20th-century-type floor-length assembly lines. Visitors will see the manufacture of the complete line of low-voltage circuit breakers and enclosures turned out by Federal. They will be shown multiple operation presses forming enclosures from rolls of sheet steel, plastic circuit breaker cases being formed in molding machines, and the assembling and testing of breakers in work centers.

International Business Machines Company (IBM), New York, N. Y. (Tuesday, Thursday, and Friday mornings, January 19, 21, and 22). This trip will afford visitors an opportunity to see the latest of IBM's large calculators. Dr. G. T. Hunter of IBM will describe the functioning of the Type 701 Data Processing Machine and will answer questions relative to its operation. The inspection will be preceded by a 20-minute film entitled "Piercing the Unknown."

Steinway and Sons, Astoria, N. Y. (Tuesday afternoon, January 19). This famous institution is celebrating its 100th anniversary this year. Visitors will see skilled craftsmen fitting the soundboards and iron frames of pianos, and stringing, installing, and regulating the keys and action. They also will see finishing, polishing, and other specialized hand work which is the heart of the piano. An unusual opportunity to witness the work of the master artisan.

CBS–Columbia, Long Island City, N. Y. (Tuesday afternoon, January 19). This is the television and radio receiver manufacturing division of the Columbia Broadcasting System, which is striving for a position among the leading manufacturers in this field. The operations at this plant are almost completely mechanized. A continuous flow of materials, subassemblies, and final assemblies makes possible daily production of 2,000 television and radio receivers.

Informal Tea

Inaugurated last year, this social gathering before the formal program begins was enjoyed by many members and guests. It is hoped that more will participate this year—on Sunday afternoon, January 17, from 4 to 6 p.m., in the Georgian Room of the Statler. There will be no charge.

During this same period the registration facilities will be open for those wishing to avoid the Monday morning rush.

Brookhaven National Laboratory, Upton, L. I., N. Y. (Wednesday all day, January 20). The most popular trip on last year's schedule will be repeated. The facilities at Brookhaven are operated by Associated Universities, Inc., under contract with the Atomic Energy Commission. This is the northeastern center for nuclear research and development in the fields of physics, chemistry, biology, medicine, and engineering. Among the exhibits to be seen will be the atomic pile model and the Cosmotron. The Brookhaven staff has made a special request that visitors be limited to those coming from out-of-town, since local mem-

Members taking the Wednesday morning tour of Lever House will inspect one of the most unique of the new office buildings erected in New York City during the past few years

CBS-Columbia, television and radio receiver manufacturing division of the Columbia Broadcasting System, will be visited during the Winter General Meeting

bers have other opportunities during the year to inspect these facilities. Members must sign up for the trip by 4:30 p.m., Monday.

Lever House, New York, N. Y. (Wednesday morning, January 20). This is one of the most unique of the many new office buildings erected in New York City during the past few years. The exterior is blue heat-absorbing glass and stainless steel. The blue glass has a functional rather than a decorative purpose since it filters out 35 per cent of the sun's heat. Many other new features make this building the essence of modern architecture. Members will make a tour of the building itself and will have an opportunity to listen to talks by engineers on the mechanical and electric equipment involved.

Bell Telephone Laboratories, Murray Hill, N. J. (Wednesday afternoon, January 20). Research in all fields of basic science is conducted at this location. Of special interest to visitors are the Microwave Laboratories, the Digital Computer, the Metallurgical Laboratories, and the New Telephone Instrument Laboratories. It also is expected that special demonstrations will be arranged for the members, to be determined by the projects under development at the time of the trip.

Electrolux Corporation, Old Greenwich, Conn. (Wednesday afternoon, January 20). This plant is an outstanding example of modern manufacturing methods applied to the mass production of high-quality vacuum cleaners. Particular emphasis is placed on automatic and mechanized materials handling, with every conceivable type of conveyor system employed to full advantage. To the electrical engineer interested in the rapid and efficient automatic transfer of materials in process of manufacture, this trip should prove to be most interesting.

Long Island Lighting Company, Hicksville, L. I., N. Y. (Thursday all day, January 21). The Central Operating Headquarters of the Long Island Lighting Company presently consists of five buildings: the Service Building, Operating Warehouse, Transportation Building, Meter and Test Building, and Station and Construction Shops. The Service Building features a circular semi-bomb-proof control center which enables system operators to control major generating stations and substations. The generating station, a first in the northeast, features an outdoor turbine, a semi-outdoor steam generator equipped to burn coal, oil, or natural gas, interchangeably or simultaneously, and a central station which will be enlarged to handle a second 90/99-megawatt unit now under construction.

New York Stock Exchange, New York, N. Y. (Thursday morning and afternoon, January 21). Two special trips, one in the morning, the other in the afternoon, have been arranged to permit AIEE members to visit the famous New York Stock Exchange. Talks on the operations at the Exchange will be followed by a technicolor movie titled "What Makes Us Tick." In addition, visitors will be allowed to watch the activities on the floor of the Exchange from the gallery.

United Nations, New York, N. Y. (Thursday morning, January 21). This trip will include the regular guided tour at a reduced rate, and will be preceded by a talk on the electric equipment by a representative of the consulting engineers who worked on the design of the buildings. Many unusual features are to be seen, such as unusual lighting effects and special acoustical treatments. A complex communication system enables listeners to hear a speech, as it is being delivered, in any one of six languages by a twist of a dial.

Westinghouse Lamp Division, Bloomfield, N. J. (Thursday afternoon, January 21). A tour of the headquarters facilities of the Westinghouse Lamp Division offers the only opportunity in the United States to see all stages of incandescent lamp manufacture under one roof. The tour, composed of small groups of AIEE members conducted around the plant by engineers, will show the processing of tungsten from raw ore through various metallurgical processes to wire and coils. The manufacture of component parts, final lamp assembly, quality control procedures, and packaging will be shown also during the tour.

Allen B. Du Mont Laboratories, Clifton, N. J. (Thursday afternoon, January 20). The Instrument and Cathode-Ray Tube Divisions plants of Du Mont offer an interesting trip for AIEE members. At the Instrument Division visitors will see the assembly of cathode-ray oscilloscopes and demonstrations of the latest models of these indispensible testing devices. At the Tube Division, the methods of manufacturing cathode-ray tubes, including picture tubes for television sets, will be shown and described.

An inspection trip has been scheduled to the Central Operating Headquarters of the Long Island Lighting Company. Shown here is the completely outdoor 90/99-megawatt turbine generator as viewed from the exector end

ETA KAPPA NU DINNER

The Annual Recognition Dinner of the Eta Kappa Nu, electrical engineering honor society, will be held Monday evening, January 18, 1954, at 6:45 p.m. in the Keystone Room of the Hotel Statler. Dress is informal. Ladies and guests are cordially invited as it is not necessary to be a member of Eta Kappa Nu to attend. Dinner, including tax and gratuities, will be $5.75 per person. Checks should be made out to "New York Alumni Chapter Eta Kappa Nu." Reservations should be sent to J. W.

(*Continued on page 83*)

Tentative Technical Program

Winter General Meeting, New York, N. Y., January 18-22

Monday, January 18

10:00 a.m. Power Generation

54-150. Minimum Excitation Limit for Magnetic Amplifier Regulating System. *J. T. Carleton, P. O. Bobo, D. A. Burt,* Westinghouse Electric Corporation

54-41. Magamp Regulator Tests and Operating Experience on West Penn Power System. *E. W. Hand,* West Penn Power Company; *F. N. McClure, P. O. Bobo, J. T. Carleton,* Westinghouse Electric Corporation

CP.* Underexcited Reactive-Ampere Limit for Modern Amplidyne Voltage Regulator. *A. S. Rubenstein, M. Temoshok,* General Electric Company

10:00 a.m. Distribution Systems and Lightning Protection

54-39. Evaluation of Test Data in Determining Minimum Design Requirements for Aluminum to Copper Connectors. *D. C. Hubbard, R. W. Kunkle, A. B. Chance,* A. B. Chance Company

54-142. Useful Methods for Determining Primary Feed Points in Future Distribution System Planning. *D. L. Hopkins, D. R. Samson,* General Electric Company

54-52. Unbalanced Loading and Voltage Unbalance on 3-Phase Distribution Transformer Banks. *H. M. Bankus, J. E. Gerngross,* General Electric Company

54-4. Lightning Surges on Overhead Distribution Lines Caused by Indirect and Direct Lightning Strokes. *R. H. Golde,* The Electrical Research Association

CP.* The New Thyrite Magne-Valve Station Arrester. *W. J. Rudge,* General Electric Company

10:00 a.m. Relays

54-147. All-Electronic Carrier-Relaying Reduces Fault Clearing Time. *H. C. Barnes,* American Gas and Electric Service Corporation; *L. F. Kennedy,* General Electric Company

54-111. The All-Electronic 1-Cycle Carrier Relaying System Over-all Operating Principles. *H. T. Seeley, N. A. Koss,* General Electric Company

54-148. All-Electronic 1-Cycle Carrier Relaying Equipment—Relay Operating Principles. *M. E. Hodges, R. H. Macpherson,* General Electric Company

54-149. Performance Evaluation of All-Electronic 1-Cycle Carrier Relaying Equipment. *W. S. Price,* American Gas and Electric Service Corporation; *R. E. Cordray, R. H. Macpherson,* General Electric Company

10:00 a.m. Chemical Industry

CP.* Short Cuts in Estimating Electrical Materials Costs for Chemical Plants. *W. E. Burpee,* Stone and Webster Engineering Corporation

CP.* Electric Variable-Speed Drives in the Chemical Industry. *J. W. Picking,* Reliance Electric and Engineering Corporation

CP.* Electrical Problems Relating to Relaying and Protection in Chemical Process Plants. *W. C. Woods, L. V. Edison,* Westinghouse Electric Corporation

CP.* Amplistat Current Regulator for Rectifiers on Chlorine Service. *J. P. Smith,* General Electric Company

10:00 a.m. Rotating Machinery

CP.* Elementary Principles of Matrix Algebra. *M. B. Reed,* University of Illinois

CP.* General Network Theory in Terms of Matrix Algebra. *M. B. Reed,* University of Illinois

54-87. Application of Network Theory to the Analysis of Rotating Machinery. Part I. Synchronous and Asynchronous Machines. *H. E. Koenig,* University of Illinois

54-88. Application of Network Theory to the Analysis of Rotating Machinery. Part II. Commutating Machines. *H. E. Koenig,* University of Illinois

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—PAMPHLET reproductions of authors' manuscripts of the numbered papers listed in the program may be obtained from AIEE Order Department, 33 West 39th Street, New York 18, N. Y., as noted in the following paragraphs.

—PRICES of papers, irrespective of length, are 30 cents to members (60 cents to nonmembers) whether ordered by mail or purchased at the meeting. Mail orders are advisable, particularly from out-of-town members, as an adequate supply of each paper at the meeting cannot be assured. Only numbered papers are available in pamphlet form.

—COUPON books in nine-dollar denominations are available for those who may wish this convenient form of remittance.

—THE PAPERS regularly approved by the Technical Program Committee ultimately will be published in the bimonthly publications and Transactions; also, each is scheduled to be published in Electrical Engineering in digest or other form.

10:00 a.m. Dielectrics and Insulation Temperature Standards

54-69. Impulse Ionization and Breakdown in Liquid Dielectrics. *G. M. L. Sommerman,* Battelle Memorial Institute; *C. J. Bute,* Bonneville Power Administration; *E. L. C. Larson,* Otter Tail Power Company. Re-presented for discussion

54-70. Effect of Electrical Discharges on the Breakdown of Solid Insulation. *T. W. Dakin, H. M. Philofsky, W. C. Divens,* Westinghouse Electric Corporation. Re-presented for discussion

CP.* General Problems Relating to the Classification of Insulating Materials. *H. F. Miller,* General Electric Company

CP.* Principles for Temperature Classification of Insulating Materials by Functional Test. *K. N. Mathes,* General Electric Company

CP.* International Activities on Thermal Evaluation of Insulation Materials. *L. J. Berberich,* Westinghouse Electric Corporation

10:00 a.m. Medicine and Biology

CP.* A Sealed-Off Betatron Doughnut for Electron-Beam Extraction. *T. H. Rogers,* Machlett Laboratories, Inc.; *D. T. Scag,* Allis-Chalmers Manufacturing Company

CP.* Instrumentation for Electrical Impedance Plethysmography. *Matthew Conrad,* Philadelphia, Pa.

CP.* An Electrical Analogue for Biological Systems. *J. Berman, R. Schoenfeld,* Sloan-Kettering Institute

CP.* X-Ray Equipment for Radio Biology. *E. D. Trout, J. P. Kelly, A. C. Lucas,* General Electric Company

10:00 a.m. Management

CP.* The Development of Managers. *Richard DeMott,* SKF Roller Bearing Company

CP.* New Horizons for Engineers. *Harold Smiddy,* General Electric Company

10:00 a.m. Electronic Control

CP.* Some Practical Applications of Photoelectric Inspection to Industrial Control. *R. C. Booth,* Electric Eye Equipment Company

CP.* An Electronic Power Supply for Integral-Horsepower Motors. *J. H. Gregson, E. G. Cossie,* Canadian Westinghouse Company, Ltd.

CP.* Performance Specifications Are Needed for Electronic Control. *B. Cooper,* General Electric Company

CP.* Performance Specifications for Regulated Drives. *F. Slamar, E. H. Vedder,* Westinghouse Electric Corporation

2:00 p.m. General Session

Tuesday, January 19

9:30 a.m. Rotating Machinery and Joint Subcommittee on Carbon Brushes

54-89. Practical Aspects of Brush Contact Stability. *W. B. Belt,* Morganite, Inc.

54-90. The Use of Microwaves in Observing Commutator and Slip-Ring Surfaces During Operation. *A. H. Ryan, S. D. Summers,* Naval Research Laboratory

54-91. Electrical Resistance of Carbon Brushes on Copper Rings. *E. I. Shobert, II,* Stackpole Carbon Company

CP.* Quantitative Analysis of Carbon-Brush Treatments Using X-Ray Photometer Absorption Method. *A. C. Titus,* General Electric Company

CP.* Air Humidity and Brush Contact Drop. *H. M. Elsey,* Westinghouse Electric Corporation

9:30 a.m. Power Generation

54-151. The Hungry Horse Project Power Development. *F. M. Wilson,* United States Bureau of Reclamation

54-152. Supervisory Control and Remote Control Help Tennessee Valley Authority Cut Operating Costs. *R. M. Alspaugh, A. P. Maness,* Tennessee Valley Authority

54-57. The OVEC Project. *Philip Sporn, V. M. Marquis,* American Gas and Electric Service Corporation

54-153. Tests and Operating Experiences at the Ottawa River Plants for the Hydro-Electric Power Commission of Ontario. *J. J. Traill, F. C. Lawson, H. C. Ross, G. B. Tebo,* The Hydro-Electric Power Commission of Ontario. Re-presented for discussion

9:30 a.m. Transmission Systems

54-5. A Simplified Approach to Steady-State Stability Limits. *W. G. Heffron, Jr.,* General Electric Company

54-14. Analyzer Interconnections for Direct Determination of Power System Swing Curves. *G. A. Bekey, F. W. Schott,* University of California

54-143. Digital Load Flow Studies. *L. A. Dunstan,* Beaverton, Oreg.

CP.* Evaluation of the Integration Method for Analysis of Nonstandard Surge Voltages. *A. R. Jones,* Westinghouse Electric Corporation

CP.* Electrical Clearances for Transmission-Line Design at the Higher Voltages. *P. L. Bellaschi,* Consulting Engineer

9:30 a.m. Factors Affecting Permissible Leakage Currents in Portable Electric Equipment

54-38. Safety in High-Voltage Testing. *A. F. Rohlfs, T. Brownlee,* General Electric Company

CP.* The Threshold of Perception Currents. *C. F. Dalziel,* University of California

CP.* The Viewpoint of the Electrical Manufacturer. *W. P. Von Behren,* General Electric Company

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* CP: Conference paper; no advance copies are available; not intended for publication in *Transactions.*

CP.* The Viewpoint of the Electrical Utility. *H. A. Brown*, Rochester Gas and Electric Company

CP.* The Viewpoint of the Electrical Equipment Merchandiser. *O. D. Johnson*, Sears, Roebuck and Company

9:30 a.m. Thermal Evaluation of Magnet-Wire Insulation

CP.* Thermal Life of Magnet-Wire Insulation. *Ralph Hall*, Phelps Dodge Copper Products Corporation

CP.* Determination of Thermal Life of Enameled Wire by Laboratory Test Methods. *F. A. Sattler*, Westinghouse Electric Corporation

CP.* A Method of Evaluating Thermal Stability of Magnet-Wire Enamel. *C. G. Currin, J. F. Dexter*, Dow Corning Corporation

CP.* Functional Evaluation of Enameled-Wire-Varnish Combinations. *H. I. Morgan, K. N. Mathes*, General Electric Company

CP.* Effects of Accelerated Aging on the Dielectric Strength and Power Factor of Magnet Wire Measured at the Aging Temperature. *H. L. Saums, W. W. Pendleton*, Anaconda Wire and Cable Company

9:30 a.m. Relays

54-113. Loss-of-Field Protection for Synchronous Machines. *R. L. Tremaine, J. L. Blackburn*, Westinghouse Electric Corporation

54-112. An Improved Transformer Differential Relay. *C. A. Mathews*, General Electric Company

54-145. More About Setting Industrial Relays. *F. P. Brightman*, General Electric Company

CP.* Single-Pole Reclosing on Shawinigan Water and Power Company 230-Kv Transmission Lines. *R. B. Reed, B. C. Hicks*, Shawinigan Water and Power Company

9:30 a.m. Electronic Power Converters

54-43. Rectifier Arc-Back Study on the Analogue Computer. *J. K. Dillard, C. J. Baldwin, Jr.*, Westinghouse Electric Corporation

CP.* Pumpless Ignitrons—Field Experience and New Developments. *R. J. Moran, E. J. Remscheid*, General Electric Company

CP.* Methods of Measuring Arc-Drop Voltage on Mercury Arc Rectifiers. *H. Winograd*, Allis-Chalmers Manufacturing Company; *W. E. Lawton*, Aluminum Company of America

9:30 a.m. Behavior of the Elusive Lumen

CP.* Economics of Lamp Operation and Replacement Under Normal and Abnormal Conditions. *E. A. Linsday*, General Electric Company

CP.* Industrial Luminaires Designed for Cleaner, Better Operation. *Eric Church*, Benjamin Electric Manufacturing Company

CP.* Commercial Luminaires Designed for Longer Life, Easier Maintenance. *Dana Rowten*, Westinghouse Electric Corporation

CP.* Discussion Forum on How the Elusive Lumen Gets Away

9:30 a.m. Telegraph Systems

CP.* Signal Corps Engineering Laboratory Facsimile Activities. *W. H. Junkelman*, Coles Signal Laboratory

CP.* A New Continuous-Feed Facsimile Scanner. *J. V. L. Hogan, G. M. Stamps*, Hogan Laboratories, Inc.

CP.* Problems in Facsimile Scanning With Cathode-Ray Tubes. *W. H. Bliss*, RCA Laboratories

CP.* Design Factors in Continuous Facsimile Recorders. *P. L. Grafstein, A. G. Cooley*, Times Facsimile Corporation

9:30 a.m. Instruments and Measurements

54-170. Thermocouple-Type Ammeters for Use at Very High Frequencies. *O. G. McAninch*, General Electric Company

54-16. A Tungsten Resistance Thermometer. *F. R. Sias, J. R. Macintyre, A. Hansen*, General Electric Company

54-171. Basic Theory and Experimental Verification of the A-C Galvanometer. *T. J. Higgins*, University of Wisconsin; *William Kneen*, Pullman Standard Car Manufacturing Company

CP.* A Comparison Standard for Electric Energy Measurement. *A. W. Spinks, T. L. Zapf*, National Bureau of Standards

2:00 p.m. Sections Committee

2:00 p.m. Synchronous Machinery

54-49. Direct Cooling of Turbine-Generator Field Windings. *C. H. Holley, H. D. Taylor*, General Electric Company

54-48. A New Fully Supercharged Generator. *S. Beckwith, L. T. Rosenberg*, Allis-Chalmers Manufacturing Company

54-92. Additional Design Features of the Fully Supercharged Generator. *B. M. Koetting, G. W. Staats*, Allis-Chalmers Manufacturing Company

54-50. Ventilation of Inner-Cooled Generators. *R. A. Baudry, P. R. Heller*, Westinghouse Electric Corporation

CP.* Test Results on an Inner-Cooled Generator. *W. C. Brenner, P. R. Heller*, Westinghouse Electric Corporation

2:00 p.m. Power Generation

54-154. Controls for Operation of Steam Turbine-Generator Units. *O. N. Bryant, C. C. Sterrett, D. M. Sauter*, Westinghouse Electric Corporation

54-155. Turbine and Boiler Protection and Interlocking on the American Gas and Electric Company System. *H. C. Barnes, C. P. Lugrin*, American Gas and Electric Service Corporation

54-40. Turbine-Generator Controls, Protections, and Accessories. *G. W. Cunningham, M. A. Eggenberger*, General Electric Company

54-37. Methods of Starting Gas Turbine-Generator Units. *W. B. Boyum, R. W. Ferguson, J. G. Partlow*, Westinghouse Electric Corporation

2:00 p.m. Wood and Steel Transmission Lines

54-35. 230-Kv Wood-Pole Transmission-Line Design. *J. J. Trainor*, Public Service Company of Indiana; *L. B. LeVesconte*, Sargent and Lundy

54-21. Foundation Stability of Wood-Pole H-Frame Structures for Transmission Lines. *R. W. Caswell, F. E. Andrews*, Commonwealth Edison Company

CP.* Problems Associated With Maintenance of Steel Transmission Towers. *L. K. Yerger*, Niagara Mohawk Power Corporation

CP.* Light Versus Heavy Transmission Steel Towers. *F. B. Di Castelbianco*, Milan, Italy

CP.* Effect of Tornados on Steel and Wood Lines. *C. A. Booker*, New England Power Service Company

CP.* Use of Aluminum Alloys for Transmission-Line Structures. *G. H. Phillips, J. E. Williams*, Aluminum Company of America

CP.* Construction Costs, Design Factors, and Operating Experience on Long-Span H-Frame Transmission Lines. *C. H. Schafer*, Pennsylvania Power and Light Company

2:00 p.m. Electrical Regulators for Industrial Machines—Characteristics and Economic Fields of Applications

CP.* Electronic Regulators. *E. J. Luoma*, Reliance Electric and Engineering Company

CP.* Rotating Regulators. *G. E. Shaad*, General Electric Company

CP.* Magnetic Amplifier Regulators. *R. W. Moore*, Westinghouse Electric Corporation

2:00 p.m. Thermal Evaluation of Magnet-Wire and Flexible-Sheet Insulation

54-71. Significant Measurements for Determining the Stability of High-Temperature Magnet-Wire Insulation. *A. L. Scheideler*, General Electric Company

54-72. Calculation of Life Characteristics of Insulation. *L. C. Whitman, Paul Doigan*, General Electric Company

CP.* Significance of Thermal Aging Tests on Varnish Impregnated Sheet Insulation. *T. W. Dakin, H. J. Philofsky, W. C. Dimens*, Westinghouse Electric Corporation

CP.* Aging Tests of Class-H Layer Insulations. *J. S. Parkinson*, Johns-Manville Corporation

CP.* Thermal Aging Tests on Silicone Rubber and Class B and H Mica Insulation. *E. J. Croop*, Westinghouse Electric Corporation

2:00 p.m. Comparison of Analogue Computers

CP.* Theory and Application of High-Speed Electronic Models. *D. H. Sheingold*, George A. Philbrick, Inc.

CP.* An Improved Electronic Function Generator. *H. C. Vivian*, Boeing Airplane Company

CP.* Servo Phase Measurements at Low Frequencies. *M. A. Miller, H. Hamer*, Electronic Associates, Inc.

CP.* Use of Flight Simulators in the Design of Aircraft Control Systems. *H. E. Blanton*, Massachusetts Institute of Technology

2:00 p.m. Marine Transportation

CP.* Nuclear Power Plants for Ship Propulsion—Description. *F. E. Crever, K. Trocki*, General Electric Company

CP.* Nuclear Power Plants for Ship Propulsion—Application. *R. L. Witzke, S. A. Haverstick*, Westinghouse Electric Corporation

CP.* Forty Years of Electrical Engineering Progress in Tankers. *L. M. Goldsmith*, Atlantic Refining Company

54-144. Series Versus Parallel Connected Generators for Multiple-Engine D-C Diesel-Electric Ship-Propulsion Systems. *J. A. Wasmund*, Westinghouse Electric Corporation

2:00 p.m. Controlling the Elusive Lumen

CP.* Mass-Production Methods Applied to Lamp Replacements and Fixture Cleaning. *Fred Vorlander*, Vorlander Lighting

CP.* The Practical, Profitable Maintenance Program at Sperry. *James Kimball*, Sperry Gyroscope Company

CP.* John Hancock Insurance Company's Program to Insure Good Lighting at Low Cost. *T. C. Sargent*, Sylvania Electric Products, Inc.

CP.* Making a Business of Lighting Maintenance. *A. Marmon*, Broadway Maintenance Company

CP.* Discussion Forum on How Simplified Maintenance Keeps the Elusive Lumen at Work

2:00 p.m. Telegraph Systems

54-105. A New Portable Telegraph Transmission Measuring Set. *S. I. Cory*, Bell Telephone Laboratories, Inc.

CP.* RCA's International Teleprinter Exchange System. *R. E. Hammond*, RCA Communications, Inc.

54-114. High-Speed Teletypewriter Equipment for the Armed Services. *C. E. Schultheiss*, Kleinschmidt Laboratories, Inc.

54-115. A Step Forward in Printing Telegraphy. *A. S. Benjamin, W. J. Zenner*, Teletype Corporation

2:00 p.m. Instruments and Measurements

54-172. A Signal Generator Using A Short-Circuit Rotor. *V. A. Orlando*, General Electric Company

CP.* A Flexible, Wide-Range Potentiometer for the Instrument Laboratory. *H. B. Brooks*, Consulting Engineer; *F. K. Harris, F. K. Schroyer*, National Bureau of Standards

CP.* A Camera Obscura for Instrument Reading. *F. K. Harris, F. D. Weaver*, National Bureau of Standards

CP.* Stabilised Power Supplies for Instrument Applications. *W. G. Amy, F. H. Krantz, A. J. Williams, Jr.*, Leeds and Northrup Company

54-173. Sheet and Plated-Metal Measurements With a Phase-Angle-Type Probe. *W. A. Yates, J. L. Queen*, National Bureau of Standards. Re-presented for discussion

Wednesday, January 20

9:30 a.m. Heat Pumps

CP.* Load Characteristics of 29 Domestic Electric Space Heating Installations in the Detroit Area. *A. E. Bush, R. P. Woodward,* Detroit Edison Company

CP.* Performance of Earth Reservoir Heat Pumps. *Merl Baker,* The Kentucky Research Foundation

CP.* Advancements in the Weathertron Program. *P. F. O'Neill,* General Electric Company

CP.* The Residential Heat Pump. *J. L. Ditzler, F. R. Benedict,* Westinghouse Electric Corporation

CP.* Discussion on Residential Heat Pump Development. *C. D. Graham,* General Motors Corporation

9:30 a.m. Synchronous Machinery

54-93. Magnetic Vibrations in A-C Generator Stators. *R. A. Baudry, P. R. Heller, L. P. Curtis,* Westinghouse Electric Corporation

CP.* Turbine-Generator Stator Winding Temperatures at Various Hydrogen Pressures. *J. R. M. Alger, C. E. Kilbourne, D. S. Snell,* General Electric Company

54-94. Temperature Drop to Resistance Temperature Detector in Stator Windings of Turbine Generators. *J. P. Jerrard,* General Electric Company

54-42. New Developments in Armature Winding Arrangements for Large Turbine Generators. *D. Harrington,* General Electric Company; *J. E. McElligott,* Palmer Electric Manufacturing Company

9:30 a.m. Switchgear

54-31. A New Hydraulic Mechanism for Power Circuit Breakers. *E. R. Perry, N. W. Morelli,* Allis-Chalmers Manufacturing Company

54-130. An Advance in Pneumatic Mechanisms for High-Voltage Power Circuit Breakers. *R. C. Van Sickle, R. N. Yeckley,* Westinghouse Electric Corporation

54-131. A Compressed-Air Circuit Breaker for Continuous Currents in Excess of 5,000 Amperes. *H. H. Rugg, J. E. Schrameck,* Westinghouse Electric Corporation

54-132. A New 115-Kv Stored-Energy-Type Capacitor Switch. *D. C. Prince,* General Electric Company; *P. Wildi, W. H. Clagett, J. Gregg,* Pacific Oerlikon Company

54-133. Guide for Application and Operation of Outdoor Metal-Clad Switchgear. *Subcommittee on Switchgear Assemblies*

9:30 a.m. Insulated Conductors

54-73. Pipe-Type Cable Installation Techniques. *R. W. Gillette,* Consolidated Edison Company of New York, Inc.; *F. M. Hull,* Detroit Edison Company

54-56. 120-Kv Self-Contained Compression Cable Installation at Montreal. *S. H. Cunha, M. P. Gunning, D. M. Farnham,* Quebec Hydro-Electric Commission

54-74. 115-Kv Pipe-Type Compression Cable Installations at Toronto, Canada. *G. E. Kewin, J. M. Blades,* Hydro-Electric Power Commission of Ontario; *G. B. Russell,* Enfield Cables, Ltd.

CP.* High-Pressure Self-Contained Gas-Filled Cable Installation. *G. B. Shanklin,* General Electric Company

9:30 a.m. A Report on Industrial Power Systems Grounding

CP.* Part I. System Neutral Grounding. *H. B. Thacker,* Westinghouse Electric Corporation

CP.* Part II. Equipment Grounding. *H. H. Angel,* Bethlehem Steel Corporation

CP.* Part III. Static Grounding and Grounding for Lightning Protection. *C. C. Saunders,* E. I. du Pont de Nemours and Company

CP.* Part IV. Earthing. *M. A. Leland,* Chairman, Working Group

9:30 a.m. Electrostatic Processes

54-174. Recent Developments in the Theory and Design of Electric Spark Machine Tools. *E. M. Williams, J. B. Woodford, Jr., R. E. Smith,* Carnegie Institute of Technology

CP.* Industrial Electrostatic Processes for Particulate Matter. *O. C. Ralston,* Bureau of Mines

CP.* Corona Currents in Electrostatic Precipitation. *G. W. Penney, E. A. Sack,* Carnegie Institute of Technology

CP.* Development of Power Supplies for Electrostatic Air Cleaners. *A. C. Fields,* Westinghouse Electric Corporation

54-175. An Automatic Voltage-Control System for Electric Precipitators. *H. J. Hall,* Research Corporation

9:30 a.m. Conference on Noise

CP.* Sources and Properties of Electrical Noise. *W. R. Bennett,* Bell Telephone Laboratories, Inc.

CP.* Signal Detection in Noise. *G. W. Preston,* Philco Corporation

CP.* The Measurement of Noise Spectra. *J. W. Tukey,* Bell Telephone Laboratories, Inc.

54-162. The Use of Instantaneous Point Sources or Green's Functions in Evaluating Electromagnetic Fields. *J. J. Smith,* General Electric Company

9:30 a.m. New Developments in Analogue Computers

CP.* Transistor Building Blocks for Analogue Computers. *H. Hellerman,* Syracuse University

CP.* A Static Ferromagnetic Memory With Microsecond Access. *I. L. Auerbach, L. G. Thompson, J. Wylen,* Burroughs Adding Machine Company

54-168. Digital Computers as an Aid in Electric Machine Design. *R. M. Saunders,* University of California

54-169. Bibliography on Data Storage and Recording. *G. L. Hollander,* Massachusetts Institute of Technology

CP.* Design Features of Two Large-Scale Analogue Computers on the West Coast. *Stanley Rogers, Dave Abramis,* Consolidated Vultee Aircraft Company

9:30 a.m. Land Transportation

54-116. Some Application Phases of the Ignitron Rectifier Locomotives on the Pennsylvania Railroad. *F. D. Brown,* Westinghouse Electric Corporation'

54-110. Rectifier Motive Power—Inductive Coordination Considerations. *E. B. King,* American Telephone and Telegraph Company; *K. H. Gordon,* The Pennsylvania Railroad; *L. J. Hibbard,* Westinghouse Electric Corporation

CP.* New Ignitron Multiple-Unit Car Equipment for the New Haven Railroad. *E. W. Ames, W. M. Hutchison, V. A. Moore,* Westinghouse Electric Corporation

54-29. A Reappraisal of the Economics of Railway Electrification. How, When, and Where Can It Compete With the Diesel-Electric Locomotive? *H. F. Brown, R. L. Kimball,* Gibbs and Hill, Inc.

9:30 a.m. Wire Communication Systems

54-101. Line Amplifiers for Community Television Systems. *K. A. Simons, D. Kirk, H. J. Arbeiter,* Jerrold Electronics Corporation

54-58. Application and Transmission Features of a New 12-Channel Open-Wire Carrier System. *K. E. Appert, R. S. Caruthers, W. S. Chaskin,* Lenkurt Electric Company, Inc.

54-102. Mechanical Aspects and Component Features of a New 12-Channel Open-Wire Carrier System. *A. G. Ewing, F. W. Frazee, Dale Welling,* Lenkurt Electric Company, Inc.

CP.* A Pole-Mounted Repeater for a 12-Channel Open-Wire Carrier System. *George Searle,* Wisconsin Bell Telephone Company

9:30 a.m. Electrochemical Processes

54-176. A New High-Current Switch for Electrochemical and Electrothermal Applications. *H. W. Graybill,* Railway and Industrial Engineering Company. Re-presented for discussion

54-178. Magnetic Amplifiers for Metering Direct Current on Electrolytic Cell Lines. *E. A. Downing,* Columbia Southern Chemical Corporation. Re-presented for discussion

CP.* Operating Experience With a Mechanical Rectifier. *J. Chamulak,* Pennsylvania Salt Manufacturing Company; *W. C. McCullough,* I-T-E Circuit Breaker Company; *J. W. Tracht,* Pennsylvania Salt Manufacturing Company

Panel Discussion—Layout of Modern Rectifier Substations for Electrolytic Plants

9:30 a.m. Mining and Metal Industry

CP.* Application of Motors and Control to Crushers. *H. A. Wright, T. Bellinger,* Allis-Chalmers Manufacturing Company

CP.* Application of Motors and Control on Ball Mills and Rod Mills. *W. H. Schwedes,* General Electric Company

CP.* Part Winding Starting of Large Motors. *E. A. E. Rich,* General Electric Company

CP.* Factors Affecting Choice of Mine Hoist Drive. *R. B. Moore,* General Electric Company

2:00 p.m. Research

CP.* Principles of Operations Research. *J. B. Lathrop,* Arthur D. Little, Inc.

CP.* An Application of Operations Research in the Power Field. *E. W. Boehne,* Massachusetts Institute of Technology

CP.* Active Research in the Development of Atomic Fuels for the Generation of Electric Power. *W. L. Cisler,* Detroit Edison Company; *A. P. Donnell,* The Dow Chemical–Detroit Edison Nuclear Power Project

CP.* Research for and by the Electric Power Industry. *J. E. Hobson,* Stanford Research Institute; *W. A. Lewis,* Illinois Institute of Technology

CP.* No Research Means No Students. *E. A. Walker,* The Pennsylvania State College

2:00 p.m. Rotating Machinery

54-20. Induction Motor Theory—Some Elementary Concepts Extending to Supra-Synchronous Speeds. *C. T. Button,* National Pneumatic Company, Inc.

54-17. Physical Concepts of Stray Load Loss in Induction Machines. *S. S. L. Chang,* New York University

54-22. Torque-Energy Relations in Induction Machines. *P. L. Alger, W. R. Oney,* General Electric Company

54-26. Induction-Generator Theory and Application. *J. E. Barkle, R. W. Ferguson,* Westinghouse Electric Corporation

54-28. Accuracy and Simplicity in Induction Motor Calculations. *J. F. H. Douglas,* Marquette University. Re-presented for discussion

2:00 p.m. Switchgear

54-134. A New Basis for Rating Power Circuit Breakers. *Working Group on Methods of Rating Power Circuit Breakers of the Subcommittee on Power Circuit Breakers*

54-32. A 10,000-Megavolt-Ampere 138-Kv Outdoor Oil Circuit Breaker. *A. W. Hill, G. B. Cushing,* Westinghouse Electric Corporation

54-135. 138-Kv Line-Dropping Field Tests. *D. L. Finneran, R. D. Allen,* Commonwealth Associates, Inc.; *L. J. Linde, A. E. Kilgour,* Allis-Chalmers Manufacturing Company

2:00 p.m. Insulated Conductors

54-11. Single-Phase Impedance to Ground in Pipe-Type Cable. *E. R. Thomas,* Consolidated Edison Company of New York, Inc.

54-75. Control of the Thermal Environment of Buried Cable Systems. *L. H. Fink,* Philadelphia Electric Company

54-76. Current-Carrying Capacity of Pipe-Cable Systems Under Steady-State and Transient Cyclical Loading. *M. Morris, R. W. Burrell,* Consolidated Edison Company of New York, Inc.

54-77. Corrosion Control of Underground Power Cable in New York. *F. E. Kulman,* Consolidated Edison Company of New York, Inc.

2:00 p.m. Industrial Power Systems

54-9. Co-ordinated Fuse Protection for Low-Voltage Distribution Systems in Industrial Plants. *J. C. Lebens,* Bussmann Manufacturing Company

54-36. Iron Conduit Impedance Effects in Ground Circuit Systems. *A. J. Bisson, E. A. Rochau,* Consolidated Edison Company of New York, Inc.

CP.* Higher Voltage Power Distribution Systems for Large Office Buildings. *H. D. Kurt, D. L. Beeman,* General Electric Company

2:00 p.m. Semiconductor Devices

CP.* A Silicon Junction Diode Sealed in Glass. *S. H. Barnes,* Hughes Research Laboratory

CP.* Silicon High-Level P-N Junction Devices. *Vernon Onarsov*, General Electric Company

CP.* A 2-Emitter Transistor With a High Adjustable Alpha. *R. F. Rutz*, International Business Machines

CP.* The Surface-Barrier Transistor. *W. H. Forster*, Philco Corporation

CP.* Junction Transistors as Controlled Switches. *R. L. Bright, G. H. Royer*, Westinghouse Electric Corporation

CP.* Noise Characteristics of P-N Junction Diodes. *D. P. Kennedy*, Raytheon Manufacturing Company

CP.* Frequency Response of Grounded-Base and Grounded-Emitter Junction Transistors. *R. L. Pritchard*, General Electric Company

2:00 p.m. Feedback Control Systems

CP.* An Extension of Frequency Domain Methods to Nonlinear Systems, Including Servomechanisms. *Howard Hamer*, Electronic Associates, Inc.

CP.* The Use of Thyratrons in Position Control Servomechanisms. *J. C. West, D. K. Partington*, The University Electrical Engineering Laboratories

CP.* Electrical Components of the Gyrotron Vibratory Rate Gyro. *J. B. Chatterton*, Sperry Gyroscope Company

54-125. Contactor Servomechanisms Employing Sampled Data. *G. K. Chow*, Pennsylvania State College

2:00 p.m. Metallic Rectifiers

54-163. Electrical Properties of Microcrystalline Selenium. *Gilbert Halverson*, Fansteel Metallurgical Corporation

54-164. Instantaneous Electrical Characteristics of Selenium Rectifiers. *G. F. Pittman, Jr.*, Westinghouse Electric Corporation

CP.* Applications of Germanium Power Rectifiers. *E. A. Harty*, General Electric Company

CP.* Evaluating Rectifiers for Magnetic Amplifiers. *D. J. Sikorra*, Minneapolis-Honeywell Regulator Company

2:00 p.m. Land Transportation

54-45. Fundamentals of Flashing of Diesel-Electric Motors and Generators. *C. A. Atwell*, Westinghouse Electric Corporation

CP.* Flashovers of Diesel Traction Motors and Main Generators. *J. R. Schoonover*, Lehigh Valley Railroad

CP.* D-C Machine Flashover Behavior. *O. C. Coho, Jr.*, General Electric Company

CP.* Summary of Report on Diesel-Locomotive Flashovers. *W. B. Miller*, Chicago and North Western Railway

CP.* Static Excitation Control for Diesel-Electric Locomotives. *S. W. McElhenny, R. M. Smith*, General Electric Company

2:00 p.m. Wire Communications

54-103. Some Engineering Considerations in the Design of Telephone Systems to Serve Predominantly Rural Areas. *T. J. McDonough, W. T. Smith*, United States Department of Agriculture

CP.* Telephone Lines for Rural Subscribers' Service. *L. Hochgraf, R. G. Watling*, Bell Telephone Laboratories, Inc.

CP.* Polyethylene-Insulated Telephone Cable—Quadded Construction. *E. R. Kerwin, F. J. Gorman*, Ansonia Wire and Cable Company

54-104. Polyethylene-Insulated Telephone Cable. *A. S. Windeler*, Bell Telephone Laboratories, Inc.

2:00 p.m. Petroleum Industry

CP.* Selection and Application of Large Motors for Petroleum Refineries. *C. M. Lathrop, E. J. Winsor*, Standard Oil Development Company

CP.* Design of a 3,000-Horsepower Explosion-proof Motor. *A. R. Gilmour*, Westinghouse Electric Corporation

54-179. Supervisory Control for Pipe-Line Pumping Stations. *M. A. Hyde, W. A. Derr*, Westinghouse Electric Corporation

2:00 p.m. Mining and Metal Industry

CP.* Remotely Controlled Bore Mining and Its Electrical Considerations. *R. R. Corner*, Carbide and Carbon Chemicals Corporation

CP.* Electric Equipment for Rotary Blast Hole Drills. *G. F. Johnson*, Joy Manufacturing Company

CP.* Electric Power Distribution and Utilization Problems at Georgetown Open-Cut Coal Mine. *R. E. Gaston*, Hanna Coal Company

CP.* Distribution and Utilization of Electric Power in Underground Mines. *Mr. Rector*, Westinghouse Electric Corporation

Thursday, January 21

9:30 a.m. Mining and Metal Industry

CP.* Characteristics and Design of Regulating Systems for 7,000-Foot-Per-Minute Tandem Cold Strip Mill. *R. G. Beadle, R. E. Manko*, General Electric Company

CP.* Characteristics and Design of the Temper Mill Drive. *A. C. Halter, T. B. Montgomery*, Allis-Chalmers Manufacturing Company

CP.* The A-C Power System at Fairless Mills. *L. L. Fountain, W. A. Derr*, Westinghouse Electric Corporation; *S. Watkins*, Gibbs and Hill, Inc.

CP.* Mercury-Arc Rectifiers for 250-Volt D-C Power Supply at Fairless Works. *D. B. Scott, Paul Triplett*, Allis-Chalmers Manufacturing Company

9:30 a.m. Rotating Machinery

54-3. Dynamic Braking of Squirrel-Cage Induction Motors. *C. F. Evert, Jr.*, University of Cincinnati

54-95. A Method of Determining Induction-Motor Speed-Torque-Current Curves From Reduced Voltage Tests. *R. F. Horrell, W. E. Wood*, Electric Machinery Manufacturing Company

54-27. Operation of 3-Phase Induction Motors on Unbalanced Voltages. *J. E. Williams*, University of Illinois

54-96. Eddy-Current Losses in Induction-Motor End-Turn Clamping Rings. *John Baird*, General Electric Company

9:30 a.m. Switchgear

54-30. A New Milestone in Circuit Breaker Interrupting Capacity 25,000,000 Kva at 330 Kv. *W. M. Leeds, G. J. Easley*, Westinghouse Electric Corporation

54-59. A 330-Kv–15,000-Megavolt-Ampere Steel-Clad Impulse Breaker to Guard the Nation's First 330-Kv Lines. *C. J. Balentine, E. B. Rietz*, General Electric Company

54-34. A 330-Kv Air Switch. *I. W. Gross*, American Gas and Electric Service Corporation; *S. C. Killian*, H. K. Porter Company, Inc.; *J. M. Sheadel*, Ohio Brass Company

54-33. Dielectric and Other Problems in the Design of a New 330-Kv Outdoor Air Switch. *A. H. Powell*, General Electric Company

CP.* A 330-Kv Disconnecting Switch. *J. B. Owens*, Westinghouse Electric Corporation

9:30 a.m. System Engineering and Power Generation

54-25. Tie-Line Power and Frequency Control of Power Systems—II. *C. Concordia, L. K. Kirchmayer*, General Electric Company

54-60. Effect of Cyclic Loads on an Interconnected System. *C. K. Duff*, Hydro-Electric Power Commission of Ontario

54-61. Load-Phase Control—Method of Automatic Frequency Control of a Multiple Generating Plants System. *Francois Cahen*, Electricite de France

54-62. Performance Tests of High-Speed Load- and Frequency-Control Equipment. *C. P. Almon, Jr., J. Donelson, Jr.*, Tennessee Valley Authority

9:30 a.m. Tubes for Ultrahigh-Frequency Television

CP.* High-Power Ultrahigh-Frequency Klystron Design and Application. *A. E. Rankin*, General Electric Company

CP.* Design Considerations for Television Tuners Using Pencil Tubes. *W. H. Harris, J. J. Thompson*, Radio Corporation of America

CP.* Ultrahigh-Frequency Amplifier Design for a Disk Seal Triode. *S. C. Peek*, Sylvania Electric Products, Inc.

CP.* Tube Evaluation at Ultrahigh Frequency. *R. L. Bailey*, General Electric Company

9:30 a.m. Magnetic Materials

CP.* Magnetic Developments in Japan. *R. M. Bozorth*, Bell Telephone Laboratories, Inc.

CP.* The Relation Between Domain Phenomena and Crystal Orientation to Design and the Use of Magnetic Materials. *L. J. Dijkstra*, Westinghouse Electric Corporation

CP.* Domain Structure in Relation to Magnetostriction and Design Factors. *P. W. Neurath*, General Electric Company

9:30 a.m. Electronic Circuit Theory Conference

CP.* Responses of Certain Basic Circuits to a Sinusoidal Wave Packet. *T. J. Higgins*, University of Wisconsin

CP.* A New Method for Realizing a Driving-Point Impedance Function. *R. H. Pantell*, Stanford University

CP.* A Supplement to the Brune Synthesis Procedure. *F. Reza*, Massachusetts Institute of Technology

CP.* Synthesis for Structure Only of a Ladder Network When the Lattice Is Known, and Is Reactive. *G. B. Hoadley*, University of North Carolina

9:30 a.m. Color Television Networking and Measurements

CP.* Differential Gain and Phase Measurements in Color Television Systems. *H. Kelly*, Bell Telephone Laboratories, Inc.

CP.* Photoelectric Colorimeter for Color Television. *J. B. Chatten*, Philco Corporation

CP.* Phase Analyzer for Color Television. *J. F. Fisher*, Philco Corporation

CP.* Transmission of Color Over Intercity Television Networks. *J. A. Rae*, American Telephone and Telegraph Company

9:30 a.m. Communication Switching Systems

54-122. A Fully Automatic Teletypewriter Switching Center for Military Use. *Leith Johnston, R. C. Stiles*, Automatic Electric Company

54-24. The Recognition and Identification of Symmetric Switching Functions. *S. H. Caldwell*, Massachusetts Institute of Technology

CP.* Switching Functions on an *n*-Dimensional Cube. *C. Y. Lee*, Bell Telephone Laboratories, Inc.

CP.* Experiences With Nation-wide Dialing at Englewood, N. J. *E. L. Getz*, Bell Telephone Laboratories, Inc.

9:30 a.m. Cathodic Protection and Storage Batteries

CP.* Electrical Grounding and Cathodic Protection at the Fairless Works. *W. E. Coleman, Harold Frostich*, United States Steel Corporation

54-180. Some Aspects of the Charge and Discharge Processes in Lead-Acid Storage Batteries. *C. N. Craig, W. J. Hamer*, National Bureau of Standards

54-177. Some Discharge Characteristics of Lead-Acid Batteries. *E. A. Hoxie*, The Electric Storage Battery Company

9:30 a.m. Extra-High-Voltage Transmission Systems

54-19. Protective Practices as a Criterion for High-Voltage Transmission Design. *H. L. Rorden, R. S. Gens*, Bonneville Power Administration

54-55. The American Gas and Electric Company 330-Kv Transmission-System Design Principles, Electrical Characteristics, and Performance. *H. P. St. Clair, C. A. Imburgia*, American Gas and Electric Service Corporation

54-54. Equipment for American Gas and Electric 330-Kv System. *F. A. Lane, J. H. Kinghorn, F. M. Porter*, American Gas and Electric Service Corporation

CP.* Report on Insulation Co-ordination. *J. H. Foote*, Chairman, Standards Co-ordination Committee Number *8*.

2:00 p.m. Mining and Metal Industry

54-107. Considerations in Applying Rectifiers as a Power Supply for Hot Strip Mills. *G. M. Zins, E. J. Cham,* Westinghouse Electric Corporation

CP.* Transient Characteristics of Metal Rolling Motors and Generators. *E. P. Smith,* General Electric Company

CP.* Ignitron Rectifier Voltage Regulators. *L. F. Stringer,* Westinghouse Electric Corporation

54-181. Electric Equipment for Slabbing Mill and Blooming Mill. *R. H. Wright, N. L. Kincaid,* Westinghouse Electric Corporation

2:00 p.m. Rotating Machinery

54-97. The Equivalent Circuit of the Schrage Motor. *C. L. Sheng,* Pennsylvania State College

54-8. Speed-Torque Calculations for Induction Motors With Part Windings. *P. L. Alger,* General Electric Company; *Y. H. Ku,* Moore School of Electrical Engineering; *C. H. T. Pan,* General Electric Company

54-15. Skin-Effect Bars of Squirrel-Cage Rotors. *M. Liwschitz-Garik,* Polytechnic Institute of Brooklyn

54-23. Switching Transients in Wound-Rotor Induction Motors. *P. L. Alger,* General Electric Company; *Y. H. Ku,* Moore School of Electrical Engineering

54-1. The Magnetic Noise of Polyphase Induction Motors. *P. L. Alger,* General Electric Company. Re-presented for discusion

2:00 p.m. System Engineering and Power Generation

CP.* Communication Systems of the Illinois-Missouri Electric Power Pool. *G. W. Fox,* Union Electric Company of Missouri; *D. F. Haten,* Illinois Power Company; *H. E. Stites,* Central Illinois Public Service Company

54-63. Load Control and Telemetering—Ohio Edison System. *R. H. Travers,* Ohio Edison Company

CP.* Design and Operation of System-wide Automatic Load-Frequency Control Equipment. *H. A. Bauman, C. N. Metcalf, J. G. Noest,* Consolidated Edison Company; *G. B. Carolus,* Leeds and Northrup Company

CP.* Steam Plant Operation Improved by Load Frequency Control. *H. C. Reasoner,* Detroit Edison Company

54-64. Principles of A-C Power-System Voltage Control for Operating Personnel. *H. B. Smith,* Niagara Mohawk Power Corporation

2:00 p.m. Substations

54-83. 330-Kv Outdoor Station for the Atomic Energy Commission. *F. W. McCloska,* Sargent and Lundy; *F. L. Musselman,* General Electric Company

54-84. Switching Surge Voltages in High-Voltage Stations. *I. B. Johnson, A. J. Schultz,* General Electric Company

54-80. A Guide for Minimum Electrical Clearances for Standard Basic Insulation Levels. *Working Group on Minimum Clearances*

54-81. Application Guide on Methods of Substation Grounding. *Working Group on Substation Grounding Practices*

54-82. A Guide to Safety Considerations in the Design of Substations. *Working Group on Safety in Substations*

2:00 p.m. Magnetic Materials

CP.* What is Ferrimagnetism? *L. R. Maxwell,* United States Naval Ordnance Laboratory

CP.* Properties and Applications of Available Ferrites. *V. E. Legg, C. D. Owens,* Bell Telephone Laboratories, Inc.

CP.* A Comparison of Metals and Ferrites for High-Frequency Applications. *D. R. Brown, D. A. Buck, Norman Menyuk,* Massachusetts Institute of Technology

CP.* High Coercive Permanent Magnet Materials and Their Application. *T. O. Paine, L. I. Mendelsohn,* General Electric Company

2:00 p.m. Present Status of Transistors

CP.* Transistor Materials. *F. J. Morin,* Bell Telephone Laboratories, Inc.

CP.* Transistor Devices. *W. C. Dunlap, Jr.,* General Electric Company

CP.* Transistor Technology. *R. L. Sherwood,* RCA Laboratories

CP.* Transistor Applications. *R. F. Shea,* General Electric Company

2:00 p.m. Color Television Transmitting Facilities

CP.* Color Television Camera Equipment. *F. W. Millspaugh,* Radio Corporation of America

CP.* Equipment for Color Television Broadcasting. *R. Popkin-Clurman,* Telechrome Corporation

CP.* Color Television Studio Design From an Operational Standpoint. *R. Montford,* National Broadcasting Company

CP.* Color Television Equipment for the Broadcaster. *O. W. B. Reed, Jr.,* Jansky and Bailey, Inc.

2:00 p.m. Insulated Conductors

54-10. Evaluation of Cable Movement Due to Cyclic Loading. *C. A. Bauer, R. J. Nease,* Commonwealth Edison Company

54-7. Tellurium Alloy Lead Sheath for Power Cable. *G. B. Shanklin, J. F. Eckel,* General Electric Company

54-78. Crepe Papers and Crepe-Paper Cables. *G. Camilli, L. Mulligan, E. L. Crandall,* General Electric Company

54-79. A Submarine Cable for 100-Kv D-C Power Transmission. *B. O. N. Hansson,* Aktiebolaget Liljeholmens Kabelfabrik

2:00 p.m. Transmission and Distribution and Protective Devices

54-156. Measuring Equipment and Techniques Used for High-Voltage Impulse Tests on Lines and Substations. *J. W. Skooglund,* Westinghouse Electric Corporation; *W. H. Kolb,* American Gas and Electric Service Corporation; *T. L. Dyer, Jr.,* Westinghouse Electric Corporation

54-51. High-Voltage Impulse Tests on Transmission Lines. *C. F. Wagner,* Westinghouse Electric Corporation; *I. W. Gross,* American Gas and Electric Service Corporation; *B. L. Lloyd,* Westinghouse Electric Corporation

54-157. High-Voltage Impulse Tests in Substations. *I. W. Gross,* American Gas and Electric Service Corporation; *S. B. Griscom, J. M. Clayton,* Westinghouse Electric Corporation; *W. S. Price,* American Gas and Electric Service Corporation

54-53. Voltage Divider for Measuring Impulse Voltages on Transmission Lines. *S. B. Griscom, B. L. Lloyd, A. R. Hileman,* Westinghouse Electric Corporation

2:00 p.m. Electronic Education

CP.* The Fundamentals of Electronics. *I. B. Baccus,* Michigan State College

CP.* Electronics Education in the Small College. *K. F. Sibila,* University of Akron

CP.* Electronics in the 5-Year Undergraduate Program. *E. M. Boone,* Ohio State University

CP.* The Effects of Recent Scientific Developments Upon Education in Electronics. *J. D. Ryder.* University of Illinois

CP.* Industry Examines Engineering Education. *A. L. Samuel, R. W. Wolslegel,* International Business Machines Corporation

Friday, January 22

9:30 a.m. Mining and Metal Industry

CP.* Electric Control for Continuous Annealing. *P. A. Travisano,* General Electric Company

CP.* Unusual Electric Drive Features Applied to Fairless Processing Lines. *E. E. Vonada,* Reliance Electric and Engineering Company

54-108. Trends in "Automation"—Electrolytic Tinning. *P. R. Gravenstreter, R. E. Layton,* The Clark Controller Company

CP.* 60-Cycle Induction Heating of Aluminum. *J. W. Hrovath,* Aluminum Company of America

9:30 a.m. Rotating Machinery

54-98. Effect of Overvoltages and Surges on Machine Insulation. *C. L. Sidway, J. E. Conner,* Southern California Edison Company

54-18. Stator Insulation Practices for High-Voltage Inner-Cooled Generators. *G. L. Moses,* Westinghouse Electric Corporation

54-99. Corona in Low-Voltage Motor Windings. *W. T. Starr,* General Electric Company

CP.* Thermal Endurance of Silicone Magnet Wire Evaluated by Test. *W. J. Bush, J. F. Dexter,* Dow-Corning Corporation

CP.* Review of Some Problems in D-C Testing Low-Voltage Electric Machine Insulation. *G. L. Moses,* Westinghouse Electric Corporation

9:30 a.m. Transformers

54-46. Parallel Windings in Multiwinding Transformers. *Saul Bennon,* Westinghouse Electric Corporation

54-117. Long-Time Scale Models of Transformers for the Determination of Transient Voltages. *P. A. Abetti,* General Electric Company; *H. B. Belck,* Rensselaer Polytechnic Institute

54-13. Fundamental Oscillations of Coils and Windings. *P. A. Abetti, F. J. Maginniss,* General Electric Company

54-118. Some Properties of the Optimum Power Transformer Design. *H. L. Garbarino,* Armour Research Foundation of Illinois Institute of Technology

54-119. A Stray Loss Problem in Transformer Tanks. *F. J. Vogel, E. J. Adolphson,* Allis-Chalmers Manufacturing Company. Re-presented for discussion

9:30 a.m. Carrier Current

54-85. A New Carrier-Current Line Trap for Power-Line Application. *F. D. Johnson, F. W. Lindsay, Zeno Neri,* Westinghouse Electric Corporation

54-2. Planning the Carrier Facilities for a Utility System. *J. C. G. Carter,* Westinghouse Electric Corporation

54-86. High-Speed Control by Frequency-Shift Audio Tones. *D. C. Pinkerton, L. C. Widmann,* General Electric Company

54-12. Application Guide for Power-Line Carrier. *Project Subcommittee Number 2 of the Committee on Carrier Current*

9:30 a.m. Feedback Control Systems

CP.* A Note on the Analysis of Backlash and Hysteresis in Feedback. *L. M. Vallese,* Brooklyn, N. Y.

CP.* Automatic Flight Control Using Rate Gyros for Unlimited Maneuvering. *C. R. Hanna, K. A. Oplinger, G. R. Douglas,* Westinghouse Electric Corporation

CP.* Cross-Coupling in 2-Channel Servos. *E. L. Peterson,* General Electric Company

54-124. The Application of Short-Time Memory Devices to Compensator Design. *D. J. Ford, J. F. Calvert,* Northwestern University

9:30 a.m. Infrared Transducer Systems

CP.* Infrared Detectors and Techniques for Comparison. *A. J. Cussen,* United States Naval Ordnance Laboratory

CP.* Some Aspects of Infrared Image Devices. *G. A. Morton,* RCA Laboratories

CP.* Instrumentation Problems With Infrared Detectors. *W. G. Fastie,* The Johns Hopkins University

CP.* Photoconductive Detectors and Transducer Systems. *R. W. Paulson,* General Electric Company

9:30 a.m. Conference on Selenium and Tellurium

CP.* A General Mode of the Selenium Semiconductor. *H. W. Henkels,* Westinghouse Electric Corporation

CP.* Surface States in Selenium. *K. Lehovec,* Sprague Electric Company

CP.* Microstructures in Selenium. *E. F. Losco,* Westinghouse Electric Corporation

CP.* Properties of Liquid Selenium. *J. Maczuk,* University of Pennsylvania

CP.* Diffusion Phenomena in Se-Metal Contacts. *A. C. English,* General Electric Company

CP.* Effects of Thallium in Counter-Electrode Materials. *H. Bandes,* Sylvania Electric Products, Inc.

9:30 a.m. Magnetic Amplifiers

54-158. Analysis of a Single-Core Magnetic Amplifier With Real Rectifier and Core Functions. *Max Frank, Saul Rabotnick, J. R. Walker*, Wayne Engineering Research Institute

54-159. Fast-Response Magnetic Amplifiers. *G. E. Hughes, H. A. Miller*, Raytheon Manufacturing Company

54-182. Design Considerations of the Half-Wave Bridge Magnetic Amplifier. *C. W. Lufcy, H. H. Woodson*, United States Naval Ordnance Laboratory

54-160. Frequency Response of a Resonant Dielectric Amplifier. *G. W. Penney, E. A. Sack, E. R. Wingrove*, Carnegie Institute of Technology

CP.* Response Time of Magnetic Amplifiers. *L. J. Johnson*, D and R Limited; *S. E. Rauch*, University of California

9:30 a.m. Television Transmitting Equipment and Special Receiving Systems

54-165. High-Gain Side-Firing Helical Antennas for Ultrahigh-Frequency Television Broadcasting. *H. G. Smith*, Cornell University

CP.* The Wavestack, a New Type of Antenna for Very-High-Frequency Broadcasting. *G. B. MacKimmie*, Radio Corporation of America

54-166. An Ultrahigh-Frequency Transmitter Employing Klystron Power Amplifiers. *W. H. Sayer*, Allen B. Du Mont Laboratories. Re-presented for discussion

CP.* An On-Channel Television Satellite System. *L. E. Rawls*, Station *WSM*

CP.* Community Television Systems. *M. F. Malarkey, Jr.*, Transvideo Corporation

9:30 a.m. System Engineering

54-65. Co-ordination of Incremental Fuel Costs and Incremental Transmission Losses by Functions of Voltage Phase Angles. *W. R. Brownlee*, Southern Services, Inc.

54-66. Loss Evaluation—I. Losses Associated With Sale Power in Phase Method. *D. C. Harker*, Commonwealth Associates, Inc.; *W. E. Jacobs*, Consumers Power Company; *R. W. Ferguson, E. L. Harder*, Westinghouse Electric Corporation

54-67. Loss Evaluation—II. Current- and Power-Form Loss Formulas. *E. L. Harder, R. W. Ferguson*, Westinghouse Electric Corporation; *W. E. Jacobs*, Consumers Power Company; *D. C. Harker*, Commonwealth Associates, Inc.

54-68. A Transmission Loss Penalty Factor Computer. *C. A. Imburgia*, American Gas and Electric Service Corporation; *L. K. Kirchmayer*, General Electric Company; *G. W. Stagg*, American Gas and Electric Service Corporation

CP.* Application of Penalty Factor Computer on American Gas and Electric System. *G. C. McDaniel, V. R. Peterson, A. H. Willenner*, American Gas and Electric Service Corporation

9:30 a.m. Switchgear

54-129. Short-Circuit Calculating Procedure for D-C Systems With Motors and Generators. *W. R. Crites, A. G. Darling*, General Electric Company

54-137. Mechanical Properties of Aluminum Electrical Bus. *G. W. Stickley, C. O. Smith*, Aluminum Company of America

54-136. Transient Voltage and Current Requirements of Main-Field Circuit Breakers for Synchronous Machines. *M. E. Horn, J. C. Cunningham*, Westinghouse Electric Corporation

54-140. Measurement of Current Density in the High-Current Arc. *W. F. Skeats, C. L. Schuck*, General Electric Company

54-138. Short-Circuit Forces in Isolated-Phase Busses. *W. R. Wilson, L. L. Mankoff*, General Electric Company

2:00 p.m. Mining and Metal Industry

CP.* Characteristics of Magnetic Amplifiers for Industrial Processes. *R. G. Beadle, B. P. Chausse*, General Electric Company

CP.* Control Equipment for Sheet Shearing Lines, Fairless Works. *R. P. Forrestal, R. J. Byrnes*, Cutler-Hammer, Inc.

CP.* A 2-Motor A-C Mine Hoist Control System. *A. H. Miles*, Electric Controller and Manufacturing Company

CP.* Performance of A-C Cranes. *R. W. Wickersham*, Westinghouse Electric Corporation

2:00 p.m. Rotating Machinery

54-100. Single-Phase Operation of a 3-Phase Motor With a Simple Phase Converter. *R. Habermann, Jr.*, General Electric Company

CP.* Calculation of Temperature Rise of Intermittent-Duty Motors With an Electronic Thermal Analogue Computer. *W. R. Hoffmeyer, E. R. Cunningham*, General Electric Company

CP.* A New Homopolar Motor. *Y. H. Ku, Ahmad Kamal*, Moore School of Electrical Engineering

CP.* Characteristics of Alnico VI in 2-Pole Permanent-Magnet Alternators. *J. M. Shulman*, Westinghouse Electric Corporation

CP.* The Revolving-Field Theory of the Repulsion Motor. *C. L. Sheng*, Pennsylvania State College

2:00 p.m. Transformers

54-120. Transformer Noise Measurement Methods. *Progress Report of Working Group on Instrumentation and Measurement*

54-47. A New Development in High-Voltage Transformers. *H. B. Hansen, F. J. Vogel*, Allis-Chalmers Manufacturing Company

CP.* Effect of Circuit Reclosing Practice on Winding Temperature Limits During Short-Circuit Conditions. *J. E. Clem*, Test Inspection Service

54-121. The Functional Evaluation of Insulation for Small Dry-Type Transformers Used in Electronic Equipment. *R. L. Hamilton, H. B. Harms*, General Electric Company

2:00 p.m. Feedback Control Systems

CP.* Impact-Moment on Method of Servo Analysis. *Ira Ritow*

54-125. Linear Compensation of Saturating Servomechanisms. *J. R. Burnett*, Purdue University, *P. E. Kendall*, Cook Research Laboratories

54-44. An Investigation of the Switching Criteria for Higher-Order Contactor Servomechanisms. *I. Bogner*, Cook Research Laboratories; *L. F. Kazda*, University of Michigan

54-126. The Transient Performance of Servomechanisms With Derivative and Integral Control. *R. C. Lathrop, D. Graham*, Wright Air Development Center

54-127. A Graphical Procedure for Determining the Gain of a Servomechanism for a Specified Maximum Modulus Less Than Unity. *T. J. Higgins*, University of Wisconsin

2:00 p.m. Symposium on High-Frequency Conductors, Cables, and Connectors

CP.* Styroflex Semi-Flexible Air-Dielectric Coaxial Cable. *E. J. Merrell, A. L. McKean*, Phelps Dodge Copper Products Corporation

CP.* Shielding of Communication Cables. *F. H. Gooding, H. B. Slade*, Okonite Company

CP.* Microstrip—A Printed Microwave Transmission System. *H. F. Engelmann*, Federal Telecommunication Laboratories, Inc.

CP.* Printed Circuits. *O. I. Steigerwalt*, Erie Resistor Corporation

54-179. An Annular Waveguide Rotary Joint With Waveguide Feed. *L. O. Breetz*, Naval Research Laboratory

2:00 p.m. Conference on Selenium and Tellurium

CP.* Selenium-Tellerium Alloys. *P. H. Miller, Jr.*, University of Pennsylvania

CP.* Thermoelectric Effect of Intrinsic Semiconductors With Lattice Defects. *S. Tanuma*, Tohoku University

CP.* Intrinsic Lattice Defects in Tellurium. *H. Fritzsche*, Purdue University

CP.* Liquid Tellurium. *A. Epstein, H. Fritzsche*, Purdue University

CP.* Substitute for Selenium in Rectifiers. *J. Cataldo*, International Rectifier Corporation

CP.* Capacity-Voltage Studies on Selenium Rectifiers. *J. Marinace*, General Electric Company

CP.* Properties of Selenium Contacts. *C. T. Niu*, Westinghouse Electric Corporation

2:00 p.m. Magnetic Amplifiers

54-161. Flux Resetting Characteristics of Several Magnetic Materials. *Hoobert Huhta*, General Electric Company

CP.* Magnetic Characteristics Pertinent to the Operation of Cores in Self-Saturating Magnetic Amplifiers. *R. W. Roberts*, Westinghouse Electric Corporation

CP.* A Curve Tracer for Displaying the B-H Characteristics of Small Toroidal Cores. *C. A. Booker, Jr.*, New England Power Service Company

CP.* On the Operation of Magnetic Amplifiers With Various Types of Loads. *L. A. Finzi, R. R. Jackson*, Carnegie Institute of Technology

2:00 p.m. Broadcast Receivers and Automatic Transmitters

CP.* Very-Small Speaker-Type Personal Broadcast Receiver. *K. James*, Emerson Radio and Phonograph Corporation

CP.* An Improved Vertical Sync Circuit. *A. J. Levine, H. Altman, L. Feit*, Federal Telecommunications Laboratories, Inc.

54-167. A Radio-Relay Remote-Control System for Frequency-Modulation Broadcast Stations. *T. R. Humphrey*, Rural Radio Network

CP.* Automatic Remote-Broadcast Stations. *S. H. VanWambeck*, Hammarlund Manufacturing Company

54-6. Torque Requirements of a Radar Antenna. *Melvin Mark*, Raytheon Manufacturing Company

2:00 p.m. Switchgear

54-139. Flexible High-Power Laboratory Capacitor Bank for Variety of Switching Tests to 65,000 Reactive Kilovolt-Amperes. *R. E. Friedrich, D. J. Burns*, Westinghouse Electric Corporation

54-141. Cantilever Loaded Insulators for Isolated Phase Bus. *K. T. Ashdown, N. Swerdlow*, General Electric Company

54-128. A Guide for the Ice Testing of Outdoor Disconnecting Switches. *Working Group of the Switches, Fuses, and Insulators Subcommittee*

CP.* High-Voltage Switching on Unit Substation Transformers. *H. S. Gates, H. G. Barnett*, Westinghouse Electric Corporation

CP.* A New 161-Kv 10,000,000-Kva Oil Circuit Breaker. *L. J. Linde, A. E. Kilgour*, Allis-Chalmers Manufacturing Company

2:00 p.m. Basic Sciences

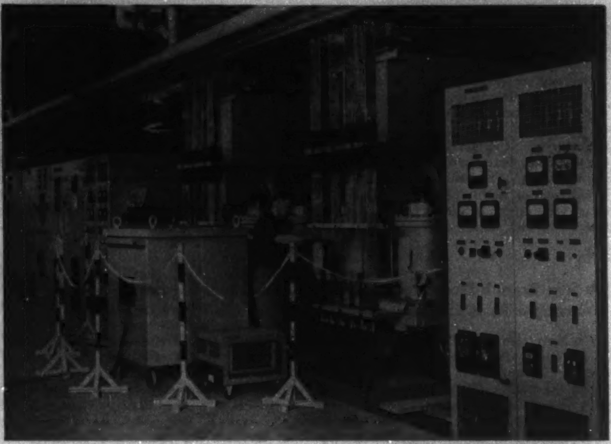
54-106. Eddy-Current Losses in a Semi-Infinite Solid Due to a Nearby Alternating Current. *H. Poritsky, R. P. Jerrard*, General Electric Company

54-146. Eddy-Current Phenomena in Ferromagnetic Materials. *H. M. McConnell*, Carnegie Institute of Technology

54-109. Flow of Energy in Synchronous Machines. *E. I. Hawthorne*, University of Pennsylvania

CP.* Characteristics of the High-Current Argon Arc With Various Electrode Materials. *J. W. Dziminski*, Allis-Chalmers Manufacturing Company; *T. B. Jones*, The Johns Hopkins University

CP.* The Measurement of Electrostatic Potential Due to Net Ion Space Change in Air. *J. S. Carroll, S. R. Hammond*, Stanford University



This control equipment for the motor-generator set which supplies 40 million watts of power to energize the magnet of the Cosmotron will be seen during the Winter Meeting inspection trip to the Brookhaven National Laboratory

(*Continued from page 76*)

Steiner, Department 2411, Federal Telecommunication Laboratories, 500 Washington Avenue, Nutley, N. J.

At the dinner, the Eta Kappa Nu Plaque designating the most outstanding young electrical engineer for 1953 will be awarded to P. A. Abetti, General Electric Company, Pittsfield, Mass. A. G. Kegel, Westinghouse Electric Corporation, Baltimore, Md., and J. E. Jacobs, General Electric X-Ray Company, Milwaukee, Wis., will be cited for Honorable Mention. The recognition was created to emphasize among electrical engineers that their service to mankind is manifested not only by achievements in purely technical pursuits, but also by contributions to their profession, community, church, and by their cultural achievements.

COMMITTEE

Members of the 1954 Winter General Meeting Committee are: C. T. Hatcher, chairman; A. J. Cooper, vice-chairman; J. J. Anderson, secretary; C. S. Purnell, budget co-ordinator; M. D. Hooven, Vice-President, District 3; L. F. Hickernell, chairman, Committee on Technical Operations; R. T. Ferris, publicity; L. F. Stone, general session; J. G. Derse, dinner-dance; D. E. Sullivan, inspection trips; C. F. Bolles, smoker; Sidney Friend, Jr., theater-radio-television; W. G. Vieth, hotel accommodations; H. E. Martin, registration; Mrs. E. S. Banghart, ladies' entertainment; R. T. Weil, monitors.

Medical Applications Discussed at Conference on Electronic Instrumentation

The sixth annual AIEE Conference on Electronic Instrumentation and Nucleonics in Medicine was held jointly with the Institute of Radio Engineers and the Instrument Society of America, November 19–20, 1953, at the Hotel New Yorker in New York, N. Y. Seventeen technical papers were presented at four enthusiastically received sessions and a lecture-demonstration on cine-radiography was well attended on the evening of the 19th.

Dr. Robert Galambos of the Department of Neuropsychiatry, Army Medical Service Graduate School, presided over the opening session, which was devoted to diagnostic devices. The first paper by Dr. J. F. Davis, Allan Memorial Institute of Psychiatry, considered multichannel electromyography, a field of medical science covering the study of muscle tension and its relation to emotional illnesses, utilizing instruments which pick up electric impulses from as many as eight body areas and after amplifying, record them simultaneously.

H. C. Becker and S. M. Peacock, Jr., Tulane University School of Medicine, described a means for quantitatively monitoring the amplitudes and waveforms of the voltage and current pulses of the electrical stimulus to stimulating electrodes imbedded in a physiological preparation. C. L. Brownell, Massachusetts General Hospital, presented "Application of Positron-Emitting Isotopes to the Localization of Brain Tumors." Brain tumors concentrate certain positron-emitting isotopes, such as As74, in a ratio of 5 to 1 over normal brain tissue. Thus in many cases, brain tumors stand out in a scan as dark areas. A sufficient number of patients have been scanned to indicate that this painless technique will be valuable in neurological examinations.

The final paper of the session was by Dr. D. H. Howry of the Veterans' Administration, and described radar-like techniques using ultrasonic mechanical waves for visualizing soft tissue structures of the body and disease processes including cancer. Pictures were shown of benign and malignant tumors and other disease processes, which cannot be visualized except by very special techniques.

X RAYS

Four papers were presented in the afternoon session over which Dr. W. E. Chamberlain, Temple University Hospital, presided.

The first paper on X rays, to which this session was devoted, concerned an isodose plotting instrument for X rays by M. Berman, M. Yonemitsu, S. Vacirca, G. Shapiro, and J. Ovadia, Sloan–Kettering Institute, Memorial Center, New York City. This instrument has two detectors, either ionization chambers or scintillation crystals, one monitoring the X-ray generator output and the other scanning the beam. The signals are amplified in preamplifiers and d-c amplifiers with negative feedback. The data appear as the ratio between the two output voltages. Three sets of selsyns supply manual or automatic remote control for the motions of the traveling probes in three mutually perpendicular directions.

S. P. Newberry, General Electric Company, described the electron microscope and told about its unique advantages. Dr. S. A. Weinberg, University of Rochester Medical School, talked about the instrumentation aspects of single-plane and stereoscopic X-ray motion pictures. In the latter, a single-camera–single-film procedure is used and a special twin-lens projector has been built for viewing the films.

W. S. Lusby, M. E. Hayes, and Z. L. Collins presented the last paper of the session on cinefluorography in which the image-amplifier tube is used. Several films were shown. In the evening session, three sequences of cineradiography were exhibited and a great deal of valuable information was exchanged between the physicians and engineers in informal discussion.

BLOOD MEASUREMENTS

Dr. Britton Chance, University of Pennsylvania Medical School, presided over the Friday morning session at which five papers dealt with the measurement and analysis of blood.

"A Method for Exact Determination of Volume Concentration of Nonconducting Particles in Conducting Solvents," was presented by H. P. Schwan and T. P. Bothwell, Moore School of Electrical Engineering, University of Pennsylvania. This method for determining red blood cell volume concentration is based on the observation that polarization impedance between metal electrodes and solution changes in proportion with the volume concentration of insulating particles.

Dr. R. L. Bowman, National Institute of Health, presented "An Instrument for Rapid Dependable Determination of Freezing Point Depression." In contrast to older methods, this method utilizes a stream of chilled air from a Ranque-Hilsch vortex tube for freezing the specimen and a thermistor-probe bridge assembly for indicating the end point.

"Blood Serum Analysis by a Quantitative Paper Electrophoresis Apparatus" was given by E. L. Durrum, Army Medical Center, and S. R. Gilford, National Bureau of Standards. The paper electrophoresis in which the charged molecules migrate along a porous paper strip under the influence of a potential field, provides a method adapted to large surveys. The paper described a recording densitometer which rapidly converts blood serum electrophoresis patterns into quantitative data on the percentage composition of the protein constituents of serum.

The last two papers of the session dealt with a method for determining action spectra of CO-inhibited respiration and an infrared analyzer for continuous respiratory CO_2 analysis.

FINAL SESSION

Dr. S. Reid Warren, Moore School of Electrical Engineering, University of Pennsylvania, presided over the final session of the conference at which four papers were presented.

The first, by R. S. Mackay, University of California Medical Center, dealt with the physiological effects of condenser discharges with application to tissue stimulation and ventricular defibrillation.

Dr. Ernest Frank, University of Pennsylvania, described a dynamic heart-body simulator, which is a high-speed electronic analogue computer designed to generate signals similar to those produced by the human heart beat. A variety of experimental studies has dealt with current fields in torso-shaped watertight containers filled with a conducting fluid in which a current dipole is immersed. (For photograph, see page 8.) Watertight electrodes, at which potentials are measured, are fixed to the walls of the torso models in which a dipole "heart generator" is positioned on the end of an insulating rod. Models are inverted to permit greater flexibility in positioning the heart generator than would be possible through the neck. The computer analyzes the torso data, which are shown on an oscilloscope in the form obtained with a human patient. There is strong evidence that the application of electrical engineering principles to the complex 3-dimensional fields associated with human heart action will provide a framework for methods of electrocardiography superior to those now practiced.

"The Application of Analogue Computer Methods to Medical Research" was given by E. P. Radford, Harvard University. The design of an artificial breathing device (a resuscitator) which would operate through a mask to provide ventilation to people unable to breathe, was to be determined. Because ten or more variables of the resuscitator and patient govern the ventilation, experiments with different types of patients and devices would require a long time to complete. A theoretical derivation of equations governing ventilation helped in defining proper characteristics of the resuscitator and a simulator was constructed to an accuracy of ±5 per cent and in a short time not only had all available resuscitators been "tested" but also various changes had been explored and final design specifications determined. Other applications of simulators to the problems of cardiovascular physiology and neurophysiology were discussed.

The final paper by E. L. Carstensen, Moore School of Electrical Engineering, University of Pennsylvania, described a method for determining the dispersion of ultrasonic velocity in liquids, which has an accuracy of the order of 1 part in 10,000 of the velocity. The method directly measures the difference between the velocity of sound in the test liquid and that of a dispersionless liquid such as water. Illustrative measurements were given for water solutions of NaCl, $CoSO_4$, $MnSO_4$, and evaporated milk.

Student Branch Dedicates Carnegie Tech Laboratory

On November 19, 1953, the Joint AIEE–Institute of Radio Engineers Student Branch and the Department of Electrical Engineering at the Carnegie Institute of Technology held an informal dedication of the school's new $100,000 Electrical Engineering Laboratory. Donated by the Westinghouse Electric Corporation, the laboratory is the only one of its kind existing in an educational institution in the world.

Featured speaker at the dedication was A. C. Monteith, Westinghouse vice-president, who discussed "The Future of the Power Industry." Mr. Monteith's talk was followed by a tour and demonstration of the new laboratory.

The laboratory will be used for education and research dealing with the detailed and advanced study of electric power systems and advanced study of a-c generators. For a description of the laboratory's features, see page 100.

Robertson Honored at Dinner Given by North Texas Section

Elgin B. Robertson, president of the AIEE, was honored on November 13, 1953, at a testimonial dinner in the Baker Hotel, Dallas, Tex., by members of the AIEE North Texas Section.

The event was dedicated "in recognition of his election to the presidency of AIEE and in appreciation of his outstanding service to the Institute, to the profession of engineering, to the business interests he represents, to his community and to his family."

John D. Harper, manager of the Rockdale Works of the Aluminum Company of America and former AIEE vice-president, gave the main address to the 140 persons present, including wives of the Section members. A portrait of Mr. Robertson was presented to him by T. D. Thomas, chief engineer of Texas Power and Light Company, as a gift from the North Texas Section.

O. S. Hockaday, personnel director of Texas Electric Service Company, was master of ceremonies and paid special tribute to Mr. Robertson's wife and mother who were present for the occasion.

21st Annual Report Is Issued by ECPD

The 21st Annual Report of Engineers' Council for Professional Development (ECPD) for the year ending September 30, 1953, has been issued.

ECPD is a federation of eight national organizations which has been organized to enhance the professional status of the engineer through co-operative efforts. The Council is concerned with the professional, technical, educational, and legislative phases of engineers' lives. Each society has three representatives on the Council and the constituent organizations are American Society of Civil Engineers (ASCE), American Institute of Mining and Metallurgical Engineers (AIME), The American Society of Mechanical Engineers (ASME), the AIEE, The Engineering Institute of Canada (EIC), American Society for Engineering Education (ASEE), American Institute of Chemical Engineers (AIChE), and The National Council of State Boards of Engineering Examiners (NCSBEE). The complete report contains a report by the chairman to the Council as well as his summary report of the Conference of Engineering Societies of Western Europe and the United States Conference on Engineering Education together with reports by each of the standing committees: Guidance, Education, Student Development, Training, Recognition, Ethics, Information, and reports of the representatives of constituent organizations. A list of "Accredited Curricula Leading to First Degrees in Engineering in the United States" also is given, together with a list of the "Canadian Engineering Curricula" as accepted by Canadian societies and professional associations of engineers as fulfilling the academic requirements for mem-

Elgin B. Robertson (left) with the portrait presented to him by T. D. Thomas (right) on behalf of the AIEE North Texas Section

bership or registration. Also included is a list of "Accredited Programs of the Technical Institute Type."

In addition to the foregoing matter, the complete report contains the ECPD Charter and Rules of Procedure, lists of the representatives of participating bodies, the personnel of standing and special committees, regional committees, the "Canons of Ethics for Engineers," and a statement of "Faith of the Engineer."

Copies of the complete ECPD 21st Annual Report may be obtained at a price of 50 cents each.

The pamphlet contains the list of "Accredited Curricula Leading to First Degrees in Engineering in the United States" and lists of "Canadian Engineering Curricula" is priced at 25 cents per copy.

A separate pamphlet containing the list of "Accredited Programs of the Technical Institute Type" is available also at a price of 25 cents per copy. All orders and remittances should be sent to Miss Elsie Murray, Administrative Secretary, Engineers' Council for Professional Development, 29 West 39th Street, New York 18, N. Y.

Summer and Pacific Meeting Will Be Held in Los Angeles

Preliminary plans for the 1954 AIEE Summer and Pacific General Meeting, which will be held in Los Angeles, Calif., June 21–25, with headquarters at the nationally famous Biltmore Hotel, are taking concrete form. The AIEE Los Angeles Section, host for the meeting, has appointed Bradley Cozzens as general chairman, and all committees under his direction have their plans well under way.

Los Angeles is an ideal center for combining vacation plans with attendance at the meeting. There will be a widely diversified schedule of technical program aItivities and, in addition, the area offers fishing, boating, and swimming, either at the ocean beaches or at mountain resorts. Both are within easy driving distance from the hotel.

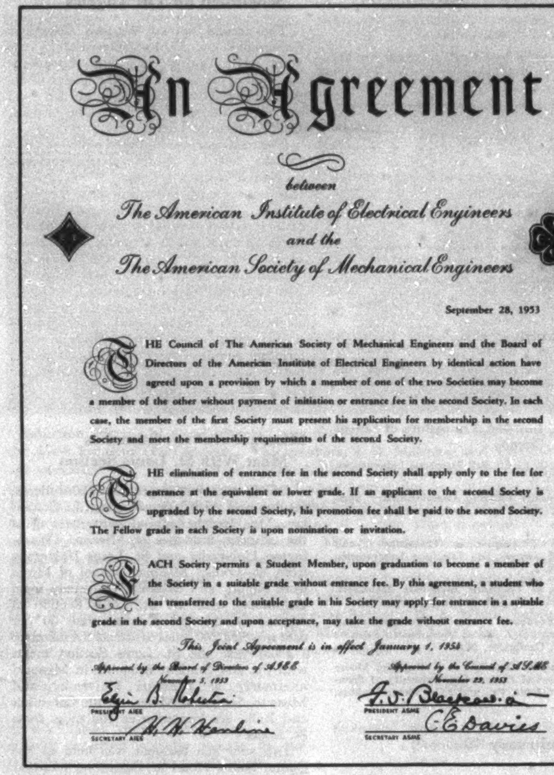
For those who do not plan to stay at the Biltmore Hotel, or in the downtown area, the motel facilities available within easy driving distance over the freeways are excellent. Parking facilities for 4,000 cars are available within the immediate vicinity of the headquarters hotel.

A program of special events for the ladies is being scheduled and will include a fashion luncheon, sightseeing trips to places of interest, a tea, and a coffee hour. Evening entertainment is being planned on a family basis, and a western-style family dinner will be held at Knott's Berry Farm.

For those who travel by train or private automobile, stopovers may be made at various spots such as Hoover Dam and Grand Canyon, and the Transportation Committee will be glad to advise as to routing and arrangements.

Members desiring further information on the plans for the 1954 Summer and Pacific General Meeting should contact: Bradley Cozzens, General Chairman, AIEE Summer and Pacific General Meeting; Los Angeles Department of Water and Power, P. O. Box 3669, Terminal Annex, 207 South Broadway, Los Angeles 54, Calif.

Reciprocal AIEE-ASME Membership Privilege



An Agreement

between

The American Institute of Electrical Engineers

and the

The American Society of Mechanical Engineers

September 28, 1953

THE Council of The American Society of Mechanical Engineers and the Board of Directors of the American Institute of Electrical Engineers by identical action have agreed upon a provision by which a member of one of the two Societies may become a member of the other without payment of initiation or entrance fee in the second Society. In each case, the member of the first Society must present his application for membership in the second Society and meet the membership requirements of the second Society.

THE elimination of entrance fee in the second Society shall apply only to the fee for entrance at the equivalent or lower grade. If an applicant to the second Society is upgraded by the second Society, his promotion fee shall be paid to the second Society. The Fellow grade in each Society is upon nomination or invitation.

EACH Society permits a Student Member, upon graduation to become a member of the Society in a suitable grade without entrance fee. By this agreement, a student who has transferred to the suitable grade in his Society may apply for entrance in a suitable grade in the second Society and upon acceptance, may take the grade without entrance fee.

This Joint Agreement is in effect January 1, 1954

Approved by the Board of Directors of AIEE
November 5, 1953

Elgin B. Robertson
PRESIDENT AIEE

H. H. Henline
SECRETARY AIEE

Approved by the Council of ASME
November 29, 1953

F. S. Blackall, Jr.
PRESIDENT ASME

C. E. Davies
SECRETARY ASME

Chicago Section Holds Students' Night Dinner

E. E. George of Ebasco Services, Inc., addressed the annual Students' Night dinner meeting of the AIEE Chicago Section on Thursday, November 19, 1953.

A feature of the meeting was the presentation of six Chicago Section members who recently were elected Fellows of the AIEE. They are J. W. Baring, F. B. Johnson, R. S. Peterson, K. M. Smith, W. W. Wishard, and J. C. Woods.

Program Announced for Conference on Transistor Circuits

A 2-day National Conference on Transistor Circuits will be held in the University of Pennsylvania Museum Auditorium, Philadelphia, Pa., on Thursday and Friday, February 18–19, 1954, under the joint sponsorship of the Institute of Radio Engineers Professional Group on Circuit Theory, and the Science and Electronics Division of AIEE. The tentative program includes 18 papers on the circuit properties of junction and surface-barrier transistors, and their use in both linear and nonlinear applications. Emphasis will be on material not previously available in the literature, and the program is designed to be of greatest value to engineers who already possess some knowledge of transistor circuit behavior.

With the University of Pennsylvania as host for the conference, its auditorium will be available for all technical sessions. Lunch will be served at the museum on both days of the conference. An informal cocktail-buffet will be held Thursday evening at the nearby Penn-Sherwood Hotel (formerly the Penn-Sheraton); this hotel also is reserving a block of rooms for out-of-town registrants.

Advance registration forms have been mailed to all members of the sponsoring groups. Anyone interested in attending who has not received advance registration forms by January 15 should request them from L. H. Good, RCA Victor, Building 10–5, Camden, N. J. Advance registration is encouraged since the facilities available for the conference are limited and final plans will be based on the number of advance registrants.

PROGRAM

The tentative technical program for the conference is as follows:

Thursday, February 18

10:00 a.m. Properties and Representation of Transistors

Chairman: J. J. Suran, General Electric Company, Syracuse, N. Y.

An Engineering View of Transistor Physics. *J. M. Early*, Bell Telephone Laboratories, Murray Hill, N. J.

A New Equivalent Circuit for Junction Transistors. *J. Zawels*, RCA Victor Division, Camden, N. J. (to be presented by H. Johnson, RCA Laboratcries, Princeton, N. J.)

Circuit Implications of Surface-Barrier Transistors. *J. B. Angell*, Philco Corporation, Philadelphia, Pa.

Variation of Junction Transistor Parameters With Operating Point and Temperature. *J. S. Schaffner*, General Electric Company, Syracuse, N. Y.

2:30 p.m. Junction Transistors in Linear Circuits

Chairman: J. G. Linvill, Bell Telephone Laboratories, Murray Hill, N. J.

Transistor Circuits Utilising Complementary Symmetry. *G. C. Sziklai*, RCA Laboratories, Princeton, N. J.

Compensation Techniques in Transistor Circuit Design. *E. R. Kretzmer*, Bell Telephone Laboratories, Murray Hill, N. J.

Neutralization of Transistor Band-Pass Amplifiers. *F. P. Keiper*, Philco Corporation, Philadelphia, Pa.

Contrasts in Feedback Theory for Transistors and Vacuum Tubes. *S. J. Mason*, Massachusetts Institute of Technology, Cambridge, Mass.

Noise in Transistor Circuits. *P. L. Bargellini*, Moore School of Electrical Engineering, University of Pennsylvania, Philadelphia, Pa., and RCA Victor Division, Camden, N. J.

Friday, February 19

9:30 a.m. Junction Transistor Amplifiers

Chairman: T. R. Finch, Bell Telephone Laboratories, Murray Hill, N. J.

Summing and Integrating Amplifiers. *F. H. Blecher*, Bell Telephone Laboratories, Murray Hill, N. J.

Transistor Power Amplifiers. *R. G. Shea*, General Electric Company, Syracuse, N. Y.

Tetrode Intermediate-Frequency Amplifiers. *L. G. Schimpf*, Bell Telephone Laboratories, Murray Hill, N. J.

Transistor D-C Amplifiers. *C. R. Hurtig*, Lincoln Laboratory, Massachusetts Institute of Technology, Cambridge, Mass.

A Carrier-Frequency Feedback Amplifier. *R. E. Yaeger*, Bell Telephone Laboratories, Murray Hill, N. J.

2:30 p.m. Nonlinear Applications of Junction Transistors

Chairman: A. W. Lo, RCA Laboratories, Princeton, N. J.

Large-Signal Low-Frequency Behavior of Junction Transistors. *J. J. Ebers*, Bell Telephone Laboratories, Murray Hill, N. J.

Transient Behavior of Junction Transistors. *J. L. Moll*, Bell Telephone Laboratories, Murray Hill, N. J.

Junction Transistor Switching Characteristics. *D. E. Deuitch*, RCA Victor Division, Camden, N. J.

Junction Transistor Switching Circuits. *J. T. Wernack*, Philco Corporation, Philadelphia, Pa.

Western Computer Conference Scheduled for Los Angeles

The second annual Western Computer Conference and Exhibit sponsored by the Joint AIEE–Institute of Radio Engineers–Association for Computing Machinery Computer Conference Committee will be held at the Ambassador Hotel in Los Angeles, Calif., February 11–12, 1954.

The conference is composed of two parallel sessions, one on control systems and one on data-processing systems. These sessions will be of wide general interest to both engineers and businessmen. One feature of the data-processing session will be the presentation of how a problem, as presented by the controller of one of the largest Los Angeles department stores, can be solved with electronic digital computing techniques.

The exhibit will demonstrate the latest electronic computing machines capable of solving problems in a few minutes which formerly required days. It is open to the public and there will be no charge for admission.

Missouri Student Branches Meet With St. Louis Section

On November 20, more than 110 students, faculty, and AIEE members met in Columbia, Mo., for the annual joint meeting of the Student Branches of Missouri (Washington University and St. Louis University from St. Louis; Missouri School of Mines from Rolla; and Missouri University from Columbia) with the St. Louis Section of AIEE. Of this group, more than 60 per cent traveled 200 miles to attend the meeting.

Each year the St. Louis Section meets with the four Student Branches in Missouri alternately at Missouri University and Missouri School of Mines. Both Columbia and Rolla are located over 100 miles from St. Louis.

This year the banquet was held at the Daniel Boone Hotel in Columbia, followed by the joint meeting which was highlighted by a talk entitled, "Engineers and Management in the American Economic System," by O. L. Luft, executive assistant, Union Electric Company of Missouri.

In the afternoon preceding the banquet the St. Louis Section Student Activities Committee met to make plans for the annual student papers contest which that Section sponsors and to discuss other student activities of that Section.

Also during the afternoon the visitors to the campus at Columbia were guided on an inspection tour of the University of Missouri's electrical engineering laboratories by Student members of the host Branch.

Fortescue Fellowship Applicants Must File by February 15

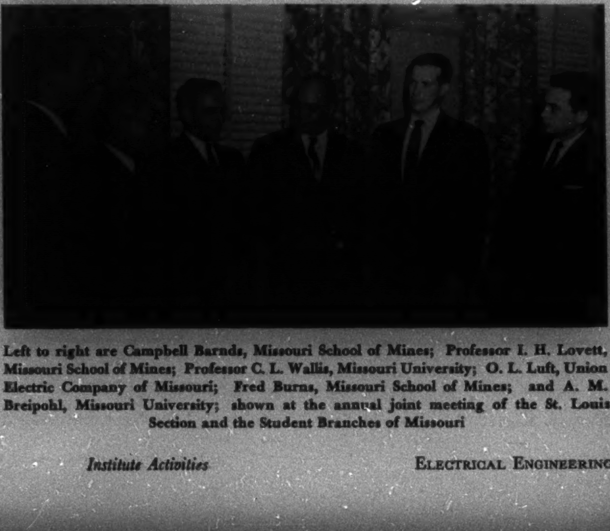
Funds have been made available for one or more Charles LeGeyt Fortescue Fellowships for 1954–55. The awards are made to postgraduate students in the field of electrical engineering who have received their baccalaureate degree from a duly recognized technical school in the United States or Canada. The amount of the award is to be determined by the committee in charge.

Candidates for the Charles LeGeyt Fortescue Fellowships should file applications on the form provided by AIEE so that they reach the secretary of the Fellowship Committee by February 15, 1954. Awards will be made not later than April 1. Copies of the application forms are available at accredited colleges or at AIEE Headquarters, 33 West 39th Street, New York 18, N. Y.

The Charles LeGeyt Fortescue Fellowship, sponsored by AIEE, was established in 1939 as a memorial to Charles Fortescue in recognition of his valuable contribution to the electric power industry. To this end the Westinghouse Electric Corporation, with which Doctor Fortescue was associated throughout his professional career, set up a trust fund of $25,000 to provide graduate fellowships in electrical engineering.

The successful candidates are selected by the AIEE committee which administers the fund.

It is intended that candidates shall pursue



Left to right are Campbell Barnds, Missouri School of Mines; Professor I. H. Lovett, Missouri School of Mines; Professor C. L. Wallis, Missouri University; O. L. Luft, Union Electric Company of Missouri; Fred Burns, Missouri School of Mines; and A. M. Breipohl, Missouri University; shown at the annual joint meeting of the St. Louis Section and the Student Branches of Missouri

their studies at accredited engineering schools and engage in research problems meeting the approval of the Fellowship Committee. To be eligible, the student must have received a bachelor's degree from an accredited college by the time his work under the fellowship would begin, provided he does not hold or subsequently receive any other fellowship which carries a stipend greater than the tuition required by the institution at which the graduate work is to be undertaken.

Bellaschi Reports European Status of High-Voltage Transmission

In a recent visit to the various engineering centers of Europe, P. O. Bellaschi (F '41), consulting engineer, had occasion to address electrical engineering societies and engineering groups in France, Italy, and England, in the countries' respective languages. Conferences were held in Milan, Italy; Paris, France; and Stafford, England, on the subject: "High-Voltage Transmission in the United States—Developments and Trends," illustrated with slides, and followed in each case by open forum discussions on relative practices, state of the art, and progress.

From these recent direct contacts and discussions abroad, Mr. Bellaschi observes that actual operation at 380 kv on the Continent and in England is about 4 or 5 years in the future, if not longer, but that rapid technical progress is being made towards this end. Also, the greater circuit mileage of transmission lines above 230 kv on the Continent and in England most probably will be of the bundle-conductor design. England now has in operation a 40-mile single-circuit bundle-conductor transmission line in the Sheffield region, operating at 275 kv (300 kv maximum), and some few hundred miles of double-circuit 275-kv bundle-conductor design are under construction. At Lecco, Italy, Mr. Bellaschi visited the transmission-line tower testing station of S.A.E. which is unique and the shop where fabrication of the towers for the Messina Strait crossing is being undertaken. In the field of 230-kv and 380-kv cable and cable terminal equipment, important progress has been made on the Continent. In fact the volume of cables and cable equipment in these voltage classes is quite impressive and speaks for itself.

As reported by the speaker, the meetings, which were called on short notice, were all well attended, and with fine response. The trip, which was undertaken at Mr. Bellaschi's initiative, represented an endeavor to cultivate better understanding among the engineering brotherhood of the various countries.

Induction Stirrer Described to Ridgway Section

"Induction Stirring of Arc Furnaces" was discussed at the November 1953 meeting of the AIEE Ridgway (Pa.) Section. The speakers, E. G. Malmlow and Quentin Graham, are president and vice-president, respectively, of the companies responsible for the first induction stirrer installation in the United States, the Aros Electric, Inc., of New York, N. Y., and the Ridgway Division of the Elliott Company. The stirrer, which was built for the Timken Roller Bearing Company of Canton, Ohio, is essentially a segment of the stator of a gigantic induction motor. Mounted under an arc furnace and energized by a low-frequency power supply, it induces currents in the molten metal which give the melt a stirring action. The more important benefits are uniformity of finished product, clearness, and close tolerance to specifications. Shown above, left to right, are: Wayne Van Vranken, chairman, Ridgway Section; H. A. White, publicity chairman, Ridgway Section; Mr. Graham; Mr. Malmlow; and J. S. Askey, program chairman, Ridgway Section

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Scintillation Counter Conference to Be Held in Washington, D. C.

The Conference on Scintillation Counters, sponsored jointly by the AIEE, Atomic Energy Commission, Institute of Radio Engineers, and the National Bureau of Standards, will be held in Washington, D. C., January 26–27, at the Shoreham Hotel.

The conference program is designed, in so far as possible, to present recent advances in scintillation counter technology. Four sessions covering various aspects of the scintillation counter field are planned. The design and performance of instruments and components will be considered, and the application of the scintillation counter to the solution of both industrial and purely scientific problems will be discussed. The tentative program is as follows. In addition to the papers listed, contributed papers are scheduled for presentation at all sessions.

Tuesday, January 26

9:00 a.m. Scintillation Counter Spectrometry

Chairman: W. H. Jordan, Oak Ridge National Laboratory

Resolution and Efficiency of the Scintillation Spectrometer. *P. R. Bell*, Oak Ridge National Laboratory

Total Absorption Gamma-Ray Spectrometry and Its Application to Betatron Experiments. *H. W. Koch*, National Bureau of Standards

2:00 p.m. Photomultipliers for Phosphors

Chairman: J. B. H. Kuper, Brookhaven National Laboratory

Some Recent Developments in Multiplier Phototubes. *R. W. Engstrom*, RCA Victor Division

New Photomultipliers for Scintillation Counting. *B. R. Linden*, Du Mont Laboratories

Scintillation Phosphors. *R. K. Swank*, Argonne National Laboratories

Evening. Round-Table Conference on Photomultipliers and Scintillators

Moderator: G. A. Morton, RCA Laboratories

Wednesday, January 27

9:00 a.m. General Applications

Chairman: D. L. Collins, Victoreen Company

Aerial Prospecting With Scintillation Counters. *G. Cowper*, Chalk River, Ontario, Canada

1:30 p.m. Cosmic-Ray and High-Energy Particle Measurements With Scintillation Counters

Chairman: L. Wouters, Radiation Laboratory, Livermore

Large-Volume Liquid Scintillators and Their Applications. *F. B. Harrison, F. N. Hayes, C. L. Cowen, S. Reines*, Los Alamos National Laboratory

Application of Scintillation Counters for High-Energy Particle Counting. *R. Hofstadter*, Stanford University

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Advance registration is requested. The fee of $2.00 should be sent, with the application, to H. O. Wyckoff, Chairman, Attendance Committee; National Bureau of Standards, Washington 25, D. C. Additional information concerning the conference can be obtained from G. A. Morton, Chairman, Scintillation Counters Symposium Committee; RCA Laboratories, Princeton, N. J.

AIEE Washington Section Presents Membership Award

At the October 1953 technical meeting of the AIEE Washington (D. C.) Section, the chairman made the first presentation of the Section's Distinguished Service Award for Promoting Membership. Sharing equal honors in receiving the award were F. Charles Luby and John P. O'Connor, both members of the Membership Committee for the initial award period, 1952–53. The names of both men were engraved on a plaque which is on permanent display in the auditorium where the Section meets, and each man was given a certificate of award. Both are serving as vice-chairmen of the 1953–54 Membership Committee.

At a meeting of the Washington Section Membership Committee in April 1952, it was agreed to set up an award for promoting Section membership. Volunteers were obtained to serve on the Incentives Subcommittee, which drafted a plan in line with the earlier expressions of committee members. With minor changes the plan was approved at the May 1952 Membership Committee meeting, and, in the same month, by the Section Executive Committee.

Presentation of the award for 1952–53 was postponed until this fall to permit activities furthering membership till the end of the Section's year to count in the competition. The presentation was synchronized with that of the Section Prize Paper Awards.

AIEE, ASME San Diego Sections Hear Gas-Turbine Discussion

Before a joint meeting of the San Diego Sections of The American Society of Mechanical Engineers (ASME) and the AIEE held on November 17, 1953, Phillip L. Ward of the Solar Aircraft Corporation discussed gas-turbine units for auxiliary power. H. O. Stone, chairman of the ASME San Diego Section, and I. E. McDougal, chairman of the AIEE Section, presided. The speaker, Mr. Ward, is chairman of the San Diego section of the Society of Automotive Engineers.

Auxiliary power turbines as used at Solar Aircraft were defined as units not normally used continuously and not in excess of 500 horsepower. Progress on various gas turbines at Solar from the time of the original twin-turbine 50-kw unit for the United States Air Force to the present Mars and Jupiter engines was reviewed by the speaker. The Mars unit is used as an auxiliary electric power unit for the Air Force *C-124* aircraft. This unit of about 50 horsepower is used also for fire-fighting on shipboard by the Bureau of Ships. The Jupiter turbine also used by the Bureau of Ships is designed for auxiliary electric power at about 500 horsepower. The basic design considerations, fuel controls, speed controls, and ignition systems were described fully by the speaker and an operational demonstration of the Mars hand-cranked fire pump unit and the electrically started power unit were given. The electric power unit delivered 18 kw with a drop of 2.5 per cent from no load to full load.

At the recent joint meeting of the AIEE and ASME San Diego Sections, P. L. Ward (right), speaker of the evening, discusses a cutaway model of the small Solar gas turbine with I. E. McDougal (center), chairman of the AIEE Section, and H. L. Stone, chairman of the ASME section

E. F. Tuck, superintendent of motive power of the Frisco Railroad (extreme right, front row), with more than 50 members of the Missouri School of Mines Joint AIEE-IRE Student Branch during their recent inspection trip through the railroad's diesel shops in Springfield, Mo.

Missouri Mines Branch Reports Recent Activities

On October 31, 1953, more than 50 students and faculty members representing the Joint AIEE–Institute of Radio Engineers Student Branch at the Missouri School of Mines and Metallurgy, Rolla, went on a trip to the Frisco Railroad's diesel-electric maintenance and repair shops in Springfield, Mo.

E. F. Tuck, superintendent of motive power for the railroad, personally conducted the tour through the diesel shops, some of which are only partially completed. The railroad's shops are some of the most modern in the country, servicing more than 400 of the railroad's passenger and freight locomotives. Also visited was the centralized traffic control system used by the Frisco to provide remote control of switches over a distance of 300 miles of the railroad's trackage.

Another highlight in the Branch's activities during the month was the visit on October 22 by AIEE Director R. F. Danner. Some 110 students, faculty members, and local citizens heard Mr. Danner speak on the construction of outdoor generating stations.

COMMITTEE ACTIVITIES

Editor's Note: This department has been created for the convenience of the various AIEE technical committees and will include brief news reports of committee activities. Items for this department, which should be as short as possible, should be forwarded to R. S. Gardner at AIEE Headquarters, 33 West 39th Street, New York 18, N. Y.

General Applications Division

Committee on Production and Application of Light (*R. L. Oetting, Chairman; J. F. Dickerhoff, Vice-Chairman; J. F. Angier, Secretary*). The committee will meet on

Tuesday, January 19, to consider plans for 1954. The meeting held in Atlantic City, N. J., last summer brought out a number of items which are of concern and interest to individual members. Some of the matters include voltage and current limits for circuits in street, sport, aviation, industrial, and commercial services. Committee procedure as to studies and presentations of these matters at future meeting sessions will be discussed during the Winter General Meeting. Those interested in such subjects are invited to meet with this committee or to contact it by mail.

Power Division

Committee on Power Generation (*J. B. McClure, Chairman; F. L. Lawton, Vice-Chairman; J. E. Barkle, Jr., Secretary*). A working group of the Excitation Systems Subcommittee continues to develop fundamental definitions pertaining to exciters and generator voltage regulators.

Working groups of the Hydroelectric Systems Subcommittee are active on the subjects of thrust bearings and early detection of fatigue failure in major components of a hydroelectric installation.

The Subcommittee on the Application of Probability Methods to Power System Problems, working in conjunction with the Edison Electric Institute, has prepared and circulated a report showing the outage rate for high-pressure steam generators and turbines.

Science and Electronics Division

Committee on Magnetic Amplifiers (*E. V. Weir, Chairman; W. J. Dornhoefer, Vice-Chairman; H. W. Lord, Secretary*). This committee is adding a West Coast Subcommittee to its subcommittee structure. The purpose of this new subcommittee is to provide better co-ordination of West Coast activities with the main committee. It is hoped that it will be in full operation very soon. If so, its first assignment will be the organization of magnetic amplifier sessions for the 1954 Summer and Pacific General Meeting in Los Angeles, Calif. A preliminary organizational meeting was held in Los Angeles in August 1953, with the main committee represented by the committee secretary.

The Subcommittee on Applications sponsored a session, consisting of five papers on magnetic amplifier applications, at the 1953 National Electronics Conference. Attendance and interest was exceptional and this committee expects to participate again in 1954.

The Subcommittee on Definitions was able to recommend definitions for 20 magnetic amplifier terms after a recent meeting held in New York, N. Y. About 20 other terms were defined and recommended for inclusion in a glossary. Where terms were found to be synonymous, a preferred term was designated.

The Magnetic Amplifier Materials Subcommittee held a meeting in New York on October 28, 1953, at which the specification for testing magnetic core materials for magnetic amplifiers were discussed and revised. In general, the subcommittee recommends that suppliers of magnetic amplifier core materials present data consisting of a d-c magnetization curve, d-c hysteresis loop, and dynamic hysteresis loops at various frequencies.

It was decided that a meeting of the Materials Subcommittee will be held at the Winter General Meeting to give consideration to the constant-current flux reset core tester as a more useful means of presenting data on magnetic materials for certain magnetic amplifier circuits.

AIEE FELLOWS ELECTED..

Board of Directors Meeting, November 5, 1953

Ralph D. Booth (AM '24, M '42), partner, Jackson and Moreland, Engineers, Boston, Mass., has been transferred to the grade of Fellow in the AIEE "for contributions as to the successful solution of problems arising in the development of electric power systems, and in the application of electric power to industry." Mr. Booth was born February 4, 1899, in Methuen, Mass., and graduated from Massachusetts Institute of Technology in 1920 with a bachelor of science degree in electrical engineering. Following his graduation he joined Jackson and Moreland as an assistant engineer and worked on various projects such as design of industrial power stations, a 22,000-volt distribution system and substation, and the design of an a-c network. From 1924 to 1927 he was responsible for economic investigations of proposed hydroelectric developments at Carillon Falls on the Ottawa River, at Conowingo on the Susquehanna, and at Passamaquoddy: investigations of the relative merits of purchased and generated power for the New York Central Railroad, for the Brooklyn-Manhattan Transit System, and the Interborough Rapid Transit System; and preliminary and fundamental plan studies for the electrification of the Great Northern Railway. He became a limited partner with Jackson and Moreland in 1927 and a general partner in 1930, responsible for engineering studies, design, and construction. Mr. Booth's work has included work on hydroelectric and steam-electric generating plants and electrical transmission facilities; wind tunnels, paper mills, machine design, and technical publications. During World War II, he served with the Office of Scientific Research and Development. In 1951 he was appointed to the Defense Production Administration Task Committee on Power Program. Mr. Booth is a registered professional engineer and is a member of the Engineering Societies of New England and the American Petroleum Institute. He has served on the AIEE Committee on Transmission and Distribution.

Francis H. Buller (AM '25, M '29), analytical engineer, General Electric Company, Schenectady, N. Y., has been transferred to the grade of Fellow in the AIEE "for contributions to the knowledge of electrical, thermal, and mechanical characteristics of electric power cable." Mr. Buller was born November 23, 1900, in Montreal, Quebec, Canada, and received his bachelor of science degree in electrical engineering from McGill University and master of science degree from Union College. Mr. Buller joined General Electric in 1923 in the test department and transferred to the transformer engineering department in Pittsfield, Mass., the next year. In 1925 he transferred again to the a-c engineering department in Schenectady, N. Y., where he worked on the design of medium-size synchronous machinery and high-frequency machinery. From 1926 to 1953 he was an application engineer with the wire and cable department. Here his responsibilities involved design and specifications of cable lines, layout of high-voltage oil-filled, gas-filled, and pipe cable lines, installation of cables and preparation of instructions for such installations; mathematical and experimental studies of problems involved in the manufacture, design, and installation of cables; development work on cable and accessories; preparation of current rating tables and other standardization work. When the General Electric Company abandoned its manufacturing of high-voltage cable in 1953, he transferred to the analytical engineering department. His work here has consisted of heat transfer studies on fuses and switchgear. Mr. Buller is a registered professional engineer and is a member of the Engineering Institute of Canada and the Corporation of Professional Engineers of Quebec.

Dale M. Farnham (M '42), chief engineer, Design Division, Quebec Hydro-Electric Commission, Montreal, Quebec, Canada, has been transferred to the grade of Fellow in the AIEE "for contributions to high-voltage underground and submarine practice in transmission and distribution systems." Mr. Farnham was born on May 17, 1899, in Nova Scotia, Canada, and graduated from Mount Allison University and Nova Scotia Technical College. After a period with the Nova Scotia Steel and Coal Company and Nova Scotia Power Commission, he was associated with Public Service Electric and Gas Company, Newark, N. J., from 1923 to 1930. In 1930 he joined the distribution engineering department of the Montreal Light, Heat, and Power, becoming assistant distribution engineer in 1931. When the company became the Quebec Hydro-Electric Commission in 1934, Mr. Farnham served as assistant distribution engineer, Engineering Design Division. He became system planning and distribution engineer in 1947, assistant chief engineer in 1951, and chief engineer in 1952. Mr. Farnham introduced into Canada insulated cables above 69-kv rating. He was responsible for the use of the first self-contained compression-type cable in Canada and for the use of the first 120-kv aluminum-sheathed oil-filled cable in Canada. His present position involves responsibility for and direction of the system planning department, transmission engineering department, substation design and construction

Ralph D. Booth

Francis H. Buller

Dale M. Farnham

department, distribution engineering department, and the relay and communication department. Mr. Farnham is a member of the Corporation of Professional Engineers of Quebec and is serving on the AIEE Committee on Insulated Conductors (1947–54).

Sherman B. Farnham (AM '36, M '42), sponsor engineering, electric utility engineering section, General Electric Company, Schenectady, N. Y., has been transferred to the grade of Fellow in the AIEE "for contributions to the solution of problems in the design and operation of electric power systems, and in the application of equipment thereto." Mr. Farnham was born on June 12, 1912, in New Haven, Conn., and was graduated from Yale University in 1933 with a bachelor of science degree in electrical engineering. He received the electrical engineering degree in 1935 also from Yale. After obtaining this degree, he joined the General Electric Company, Schenectady, where he tested radio transmitters, mercury-arc rectifiers, ordnance control equipment, and did development work on vacuum tubes and radio receiver circuits. After a year he transferred to the switchgear department, Philadelphia, Pa., as a proposition engineer. He returned to Schenectady in 1937 as an application engineer, central station engineering department. His work in this department involved preliminary engineering and preparation of proposals covering electric apparatus for foreign installations; application of lightning arresters, expulsion protector tubes, and ground-fault neutralizers; power system analysis; design, co-ordination, and application of complete factory-assembled substations in all voltage classes, and responsibility for over-all design of complete mobile substations built into railway cars and highway trailers. In 1945 he was named senior sponsor engineer responsible for application of capacitors and solutions to associated system problems and for engineering contacts with principal engineers of electrical utility systems in an assigned area. Mr. Farnham has developed means for calculating electrostatic unbalance of transmission lines for determining transpositions necessary for successful application of ground-fault neutralizers, prepared application data pertaining to transformers and unit substations to facilitate the application of preferred standard ratings in preference to special designs, and collaborated in developing and applying a high-speed automatic load regulator for turbine generators. Mr. Farnham is a member of the AIEE Committee on System Engineering (1951–54).

Richard G. Jewell (AM '30, M '43), supervisor—meter development engineering, General Electric Company, Lynn, Mass., has been transferred to the grade of Fellow in the AIEE "for accomplishments in the design and invention of electric measuring instruments, especially as applied to the aircraft field." Mr. Jewell was born on October 17, 1906, in Hillsboro, Wis., and graduated from the University of Wisconsin in 1929 with a bachelor of science degree in electrical engineering. He joined General Electric in Schenectady, N. Y., that same year on the test program. He went to Lynn in 1930 and worked on switchboard and portable instrument design. From 1935 to 1940 he was development and design engineer on aircraft instruments. He was responsible for the development of the d-c selsyn and its application to position indication pressure indicator and fuel quantity gauges, and for putting them into production, and also was responsible for the development of the General Electric remote indicating tachometer which involved the development of a small 3-phase generator and a small synchronous motor capable of running synchronously over a wide range of frequency and voltage. He was development engineer having responsible charge of the aircraft instrument development section from 1940 to 1952. During this time, development took place on electrically driven gyroscopic instruments, capacitance-type fuel quantity gauges, fluid flowmeter, and new electrical-type position indicators. Since 1952 he has been supervisor—meter development engineering, responsible for conceiving new ideas in the field of electric metering and for guiding the various developments to obtain samples having satisfactory performance. Mr. Jewell is a member of Tau Beta Pi, Eta Kappa Nu, and Phi Kappa Phi.

Jesse E. Jones (M '40), manager of drafting, Cutler-Hammer, Inc., Milwaukee, Wis., has been transferred to the grade of Fellow in the AIEE "for contributions made to the field of control and regulating systems as found in industrial, naval, and marine applications." Mr. Jones was born December 20, 1902, at Gilberts, Ohio, and graduated from Ohio State University in 1928 with a bachelor of science degree in electrical engineering. After graduation he joined Cutler-Hammer as a student engineer. In 1930 as a member of the engineering department, he designed electric control systems for elevators, skip hoists, and other conveying equipment. Later he designed electric motor controls for the graphic arts industry and for high-speed newspaper printing presses. He designed a-c and d-c control for wide-speed range presses with adaptability to a wide range of load conditions. He developed an electric plugging system for wound-rotor motors using motor secondary electrical impulses and incorporated it into a line of graphic arts control. From 1935 to 1937 Mr. Jones worked on motor control design principally for the textile and paper industries. His most involved electrical design problem was a high-speed sectional paper-making machine using an adjustable-voltage system, with adjustable-voltage section acceleration and differential section regulation. In 1937 he served as assistant supervisor of the department working on continuous processing lines for the paper, textile, and steel industries. The first high-speed continuous cloth-printing range drive control was typical of the type of control apparatus he designed. From 1942 to 1945 he served as assistant supervisor on navy and marine control. He participated in the design of the first variable-voltage towing winch control and in subsequent improvements on a large volume of this apparatus. Mr. Jones became engineering supervisor in 1945 responsible for control design for the paper and textile industries, for adjustable-voltage control for continuous processing equipment such as in steel mills and other types of control equipment. He designed magnetic ampli-

Sherman B. Farnham

Richard G. Jewell

Jesse E. Jones

Marvin M. Morack

Albrecht Naeter

Richard C. Sogge

fier regulator circuits into some of their first industrial control applications. He was promoted to manager of drafting in 1951. This department does all of the mechanical design of control components, makes panel layouts, and the electrical diagrams for the control systems. Mr. Jones is a member of Tau Beta Pi, Eta Kappa Nu, and the Engineers Society of Milwaukee. He is serving on the AIEE Committee on Marine Transportation (1947–54).

Marvin M. Morack (M '42), product application engineer, General Electric Company, Schenectady, N. Y., has been transferred to the grade of Fellow in the AIEE "for contributions in the development of mercury arc rectifiers and their application to electronic frequency conversion and variable speed power drives." Mr. Morack was born September 5, 1904, in New London, Wis., and graduated from the University of Wisconsin in 1928 with a bachelor of science degree in electrical engineering. Mr. Morack started his professional career in the testing department of General Electric, Schenectady, in 1928. After a year he transferred to the radio engineering department where he did development work on power rectifiers, thyratron inverters, and electron tube control devices. In 1930 he transferred to the power rectifier engineering department to do additional development engineering work on power rectifiers, high-frequency inverters, electronic exciters for synchronous machines, thyratron motors, and thyratron theater dimming controls. In 1934 he was assigned responsibility for design and application of the first commercial 5,000-kw 30,000-volt constant d-c power transmission system in the United States. In 1939 he was promoted to rectifier engineer and made responsible for design and development of sealed ignitron rectifiers as applied to the general industrial, electrochemical, and mining fields. In 1945 he was made the product application engineer of the industrial engineering section, apparatus sales and engineering department. Here he is responsible for increasing the usefulness of existing electronic devices and for finding and developing new electronic power converter applications in industrial, electrochemical, mining, and transportation fields, and including electronic frequency changers, electronic exciters, electronic d-c motor drives, electronic power equipment for synchrotrons, and a-c/d-c locomotives. His work includes the broad standardization functions as related to ratings, types, and construction of all types of rectifiers. Mr. Morack is serving on the AIEE Committee on Electronic Power Converters (1953–54).

Albrecht Naeter (AM '23, M '30), professor and head, School of Electrical Engineering, Oklahoma Agricultural and Mechanical College, Stillwater, has been transferred to the grade of Fellow in the AIEE "for achievement in co-ordinating effective technical teaching with educational administration and direction of collegiate research." Professor Naeter was born March 21, 1894, at New Baden, Tex., and received his bachelor of science degree from the University of Texas in 1917 and his masters degree from Cornell University in 1923. In 1917 he joined Westinghouse Electric Corporation, East Pittsburgh, Pa., and attended the engineering and design schools which were conducted by B. G. Lamme. From 1919 to 1923 he was an instructor in electrical engineering at Cornell University, Ithaca, N. Y. He held a 1-year appointment as associate professor of electrical engineering with the University of North Carolina, Durham, in 1923. The next year he was instructor in charge of the dynamo laboratory at Pratt Institute, Brooklyn, N. Y. During the summers from 1919 to 1925 he worked in the test department of the New York Edison Company. From 1925 to 1929 he was associate professor of electrical engineering, Michigan State College, East Lansing. Since 1929 he has been professor and head of the School of Electrical Engineering at Oklahoma Agricultural and Mechanical College. He has supervised and planned the courses of instruction for the communications and power options of the school and the graduate work leading to advanced engineering degrees. Professor Naeter also participates in the planning and development of laboratory and classroom facilities for the school and in the preparation and administration of its budget. He is a member of the American Society of Engineering Education, Eta Kappa Nu, and Tau Beta Pi. Professor Naeter has served as chairman of the Oklahoma City Section of the Institute, as vice-chairman of both the Oklahoma City and Tulsa Sections, and as counselor of the Oklahoma Agricultural and Mechanical College Student Branch, and on the following AIEE committees: Education (1936–37); Student Branches (1940–43); and Safety (1943–51).

Richard C. Sogge (M '35), manager—standards, General Electric Company, Schenectady, N. Y., has been transferred to the grade of Fellow in the AIEE "for achievement in national and international electrical standardization." Mr. Sogge was born on April 20, 1895, in Leland, Mich., and graduated from Ferris Institute in 1913. After completing his college work, Mr. Sogge spent 2$^{1}/_{2}$ years in miscellaneous electrical work, first as a station operator with the Leland Light and Power Company, then as electrician for Redpath Chautauqua, Chicago, Ill. He joined General Electric in 1916. During World War I he was a second lieutenant in the United States Army. After the war he returned to the transformer department of General Electric, Pittsfield, Mass. He was transferred soon to the Cleveland (Ohio) sales office where he was given the responsibility for sales to Cleveland Electric Illuminating Company, Cleveland Railway, and Municipal Plant, City of Cleveland, involving all types of electric apparatus for generation, transmission, and use of electric energy. In 1925 he was transferred to Schenectady as assistant to manager, central station department. In 1934 he was promoted to manager, Customer Division, responsible for business from electrical utilities and contractors. He was promoted to assistant manager—Central Station Divisions in 1945 and became manager of the Standards Division in 1947. In 1952 the Standards Division was renamed the Standards Service Department of the Engineering Services Division and its responsibilities enlarged. As manager of this department, some of Mr. Sogge's duties are to maintain effective relationships with approved government, professional, and industry standards groups;

John D. Stacy

William R. Way

Charles A. Woodrow

prepare and issue company standards; and promote usefulness and interchange of standards information. Mr. Sogge is a member of several committees of the National Electrical Manufacturers Association, the American Standards Association, and the National Fire Protection Association, and is a member of the International Association of Electrical Inspectors and International Municipal Signal Association. He is presently serving as president of the United States National Committee of the International Electrotechnical Commission. Mr. Sogge has served on the AIEE Committees on Standards (1947–49) and Safety (1952–54).

John D. Stacy (M '38), manager, advance and development engineering subsection, capacitor department, General Electric Company, Hudson Falls, N. Y., has been transferred to the grade of Fellow in the AIEE "for leadership in development, design, and standardization in the manufacture of capacitors." Mr. Stacy was born on September 14, 1895, in Hume, N. Y., and graduated from Rensselaer Polytechnic Institute in 1917 with a bachelor of science degree in electrical engineering. After a year as an instructor at Rensselaer, he went to the General Electric Company, Pittsfield, Mass., as a testing engineer. A year later he transferred to the capacitor department where he did design and development work on capacitor units for power-factor correction and radio applications. In 1929 he was transferred to Schenectady, N. Y., and named assistant to designing engineer of radio receiver design. When this work was transferred to RCA Victor, Mr. Stacy was transferred there and later promoted to engineer in charge of the receiver division. In 1934 he returned to General Electric to resume his work on the design of capacitor units and equipments. He soon was named design engineer in charge of the capacitor section. In 1943 he became assistant division engineer of the Capacitor Division responsible for development, standardization, and cost reduction in the Division. In 1952 he was named manager of engineering, planning, and development of the capacitor department, responsible for the development program, cost reduction, engineering budget and control, and patent contacts. Some of the improvements in capacitors that have been made under Mr. Stacy's supervision are development of drawn and seam-welded cases for distribution capacitor units; development and design of drawn and double-seamed cases for small capacitors; application of glass bushings to distribution capacitors; application of silicone elastomer to small capacitor bushings; welded assembly of capacitor roll leads to bushings; and welded assembly of silicone elastomer bushings. Mr. Stacy has served as a representative on the National Electrical Manufacturers Association Specialty Capacitor Section. He is a member of Sigma Xi.

William R. Way (M '42), vice-president in charge of generation and transmission, Shawinigan Water and Power Company, Montreal, Quebec, Canada, has been transferred to the grade of Fellow in the AIEE "for contributions to the electrical industry in the administrative and technical development of utility engineering and operating practices and intersystem collaboration." Mr. Way was born on May 29, 1896, in North Bay, Ontario, Canada, and graduated from McGill University in 1918 with a bachelor of science degree in electrical engineering. After a brief service as a lieutenant in the Royal Canadian Engineers, he joined the Shawinigan Water and Power Company as assistant engineer in the operating department. In 1924 he was transferred to Shawinigan Falls as chief system operator. In 1930 he became assistant superintendent of operation, and subsequently superintendent of operation, and assistant general superintendent. He was appointed general superintendent in charge of the generation, transmission, system operation, system planning, and communication departments in December 1944. He was appointed to his present position in 1951. Mr. Way's leadership has kept his company's technical progress well abreast of general utility practice and in many cases he has encouraged development of certain types of equipment and its use well in advance of general acceptance. This is exemplified by the application of airblast circuit breakers for the protection of high-voltage systems, the use of gas-detector relays for the protection of power transformers, the extensive use of static capacitors for power factor correction and to increase transmission capacity, and items of a similar nature. Mr. Way also has been a leader in the movement toward intersystem collaboration in Canada. He is a member of the Engineering Institute of Canada, the Canadian Electrical Association, Edison Electric Institute, Corporation of Professional Engineers of Quebec, and the Electrical Club of Montreal. Mr. Way has served as vice-president, District 10, of the AIEE (1951–53), and on the Committees on Power Generation (1945–46), Membership (1947–49), and System Engineering (1951–53).

Charles A. Woodrow (M '40), electric utility engineer, General Electric Company, Schenectady, N. Y., has been transferred to the grade of Fellow in the AIEE "for contributions in the electrical utility fields of transmission, power system analysis and standardization of ratings of large power circuit breakers." Mr. Woodrow was born on April 26, 1903, in Des Moines, Iowa, and received his bachelor of science degree in engineering from the University of California in 1926. After a period with the test department, General Electric Company, Schenectady, he transferred to the high-voltage laboratory and later worked on the design of transformers in the transformer engineering department. In 1927 he transferred to the central station engineering department working on problems of power distribution, system stability, and relaying. In 1932 he was transferred to the switchgear department, Philadelphia, Pa., to manage the sale of large power circuit breakers. He returned to Schenectady in 1941 as senior sponsor engineer in the headquarters application engineering organization. In this work he is responsible for the engineering contacts with the principal engineers in the electrical utility companies in New York City, New Jersey, Pennsylvania, Maryland, Delaware, West Virginia, and Virginia. This involves frequent visits for consultation on a wide variety of engineering problems such as system planning, system stability, operating problems, lightning protection, system relaying, and over-all projects of complete generating stations and substations. Mr. Woodrow has developed a network grounding reactor that served as a source of ground current for relaying and at the same time prevented excessive voltage rise on the high-voltage circuit. One of the results of his work on system stability was a circuit arrangement for power systems that would introduce additional reactance in the circuit that was faulted in a power system, thereby reducing the short-circuit current and the shock to the system with consequent increase in system stability limits. Mr. Woodrow is a member of Eta Kappa Nu and Tau Beta Pi.

Items on Joseph Ashmore, R. S. Daniels, and Leslie Greenwood, also transferred to the grade of Fellow by the Board of Directors on November 5, 1953, will appear in a future issue.

AIEE PERSONALITIES.....

J. F. Peters (M '14, F '23, Member for Life), consulting engineer, Westinghouse Electric Corporation, East Pittsburgh, Pa., has been awarded the Edison Medal for 1953 "for his contributions to the fundamentals of transformer design, his invention of the Klydonograph, his contributions to military computers and for his sympathetic understanding in the training of young engineers." The Edison Medal will be presented to Mr. Peters during the general session at the AIEE Winter General Meeting, January 18, 1954, in New York, N. Y. Mr. Peters was born on September 11, 1884. He grew up on a farm near Chambersburg, Pa., where he worked immediately after completing grade school. Because of his financial condition, he was unable to attend either high school or college. In 1905 Mr. Peters left the farm and found employment as a night electrician at the Pittsburgh (Pa.) Steel Company. A few months later, he

J. F. Peters

entered the employ of the Westinghouse Electric Corporation with whom he remained until his retirement in 1950. Mr. Peters started his Westinghouse career as an armature winder and about a year later was transferred to the transformer engineering department. In 1917 he became technical assistant to the manager of the transformer engineering department and in 1926 he became the first Westinghouse employee with the title of consulting engineer, a position he held until his retirement in 1950. In this capacity, he has been of assistance in a wide variety of problems covering the electrical utility and industrial fields and later the military field. Since his formal retirement, he has been retained by the Westinghouse Electric Corporation on a part-time basis for consultation on special projects.

A. N. Goldsmith (M '15, F '20, Member for Life), editor, Institute of Radio Engineers (IRE), New York, N. Y., has been awarded the Founders Award by the IRE. The award, which is given only on special occasions to an outstanding leader in the radio industry, was bestowed on Dr. Goldsmith "for outstanding contributions to the radio engineering profession through wise and courageous leadership in the planning and administration of technical developments which have greatly increased the impact of electronics on the public welfare." Presentation of this award will be made at the annual banquet during the IRE's 1954 national convention. Born in New York City in 1887, Dr. Goldsmith received his doctor of philosophy degree from Columbia University in 1911 and an honorary doctor of science degree from Lawrence College in 1935. He was professor of electrical engineering at the College of the City of New York from 1918 to 1923 and became associate professor of electrical engineering at that institution, with life tenure, in 1923. He was consulting engineer, General Electric Company, 1915–17; director of research, Marconi Wireless Telegraph Company of America, 1917–19; director of research department, Radio Corporation of America (RCA), 1919–22; chief broadcast engineer, RCA, 1922–23; vice-president, RCA Photophone, 1928–29; vice-president and general engineer, RCA, 1927–33; and subsequently has been consulting engineer. Dr. Goldsmith received the Modern Pioneer Award from the National Association of Manufacturers in 1940, the IRE Medal of Honor in 1941, the Townsend Harris Medal from the College of the City of New York in 1942, the Medal Award of the Television Broadcasters Association in 1945, and the Radio Pioneers 1952 Special Citation. He is a cofounder of the IRE and has served as president and secretary of that organization. He is a past president of the Society of Motion Picture and Television Engineers.

A. N. Goldsmith

W. R. Hewlett

H. E. Mahan

F. R. Kappel

W. R. Hewlett (AM '40, M '47), vice-president, Hewlett-Packard Company, Palo Alto, Calif., has been elected president of the Institute of Radio Engineers for 1954. Mr. Hewlett was born in 1913 at Ann Arbor, Mich. He received his bachelor of arts degree from Stanford University in 1934. After a year of graduate work at Stanford, he enrolled at Massachusetts Institute of Technology where he received the degree of master of science in 1936. In 1939 he received the electrical engineering degree from Stanford, after spending the period from 1936 to 1938 engaged in electromedical research in Palo Alto, Calif. In 1939, Mr. Hewlett joined David Packard in organizing the Hewlett-Packard Company. In 1942 he was called to active duty in the United States Army and was assigned to the Technical Division of the Office of the Chief Signal Officer in Washington, D. C., for the next 3 years. He was transferred then to the New Development Division of the War Department's Special Staff where he served as head of the electronics section. In 1945 he was a member of the Compton Mission, which was sent to Japan immediately after the surrender to form a quick appraisal of the Japanese scientific war effort. In December of that year he returned to the Hewlett-Packard Company and has continued his activities there. Mr. Hewlett is a member of Sigma Xi and has served on the AIEE Committee on Television Broadcasting Systems (1949–51).

H. E. Mahan (AM '28, M '52), manager, Illuminating Laboratory, General Electric Company, Lynn, Mass., has retired after more than 43 years' service with the company. Mr. Mahan is an international authority on outdoor lighting. A native of Philadelphia, Pa., he is a graduate of Drexel Institute of Technology with a bachelor of science degree in electrical engineering. He joined General Electric in 1910 as an application engineer and since has played an important part in nearly every lighting job installed by the company. In 1915 Mr. Mahan participated in lighting the Panama Pacific International Exposition at San Francisco, Calif., and was closely associated with exposition illumination at the Century of Progress in Chicago, Ill., and the 1939 Golden Gate International Exposition in San Francisco. In 1926 he investigated the lighting requirements for night landings on aircraft carriers for the United States Navy. He has studied lighting standards in Europe and South America. Mr. Mahan is a member of the Illuminating Engineering Society and has served on the AIEE Committee on the Production and Application of Light (1935–36, 1940–53).

F. R. Kappel (M '43, F '50), vice-president, American Telephone and Telegraph Company, New York, N. Y., has been elected president of Western Electric Company, effective January 1, 1954. Mr. Kappel, a native of Minnesota and a graduate of the University of Minnesota, has been vice-president of American Telephone and Telegraph in charge of operation and engineering since 1949. He entered the Bell System in 1924 as a groundman with the Northwestern Bell Telephone Company and thereafter held a number of engineering and operating positions. He was elected a vice-president and director of Northwestern Bell in 1942. In 1949 Mr. Kappel transferred to the parent company in New York where he served as assistant vice-president in the operating and engineering department and as vice-president in charge of the long lines department before moving to the post he now leaves. Mr. Kappel is a member of Eta Kappa Nu.

H. A. Winne (AM '16, F '45, Member for Life), vice-president, General Electric Company, Schenectady, N. Y., has received the Manufacturers Medal, James H. McGraw Award for Electrical Men. Mr. Winne received the award in recognition of his outstanding industrial statesmanship contributing to the advancement of the electrical manufacturing industry in the fields of engineering and nuclear research. Mr. Winne's retirement as a General Electric vice-president has been announced also. Mr. Winne has been on special assignments for the president of the company since May 1953. One of the country's leading experts in the field of atomic energy, Mr. Winne has served as a consultant to the Committee on Atomic Energy and on the scientific manpower board of the National Security Resources Board. A native of Cherry Valley,

N. Y., Mr. Winne was graduated from Syracuse University in 1910 with the degree of electrical engineer and joined General Electric that year. In 1911 he was made head of the large motor, generator, and synchronous converter test, and about a year later became assistant night foreman of the testing department. Five years later he was promoted to the power and mining engineering department. In 1922 Mr. Winne was transferred to the steel mill section of the industrial engineering department and became head of that organization 8 years later. Mr. Winne was elected vice-president in October 1941 and was placed in charge of design engineering for the apparatus department. In September 1945 he was appointed vice-president in charge of engineering policy for the entire company. Mr. Winne is a fellow of The American Society of Mechanical Engineers and a member of the American Society for Engineering Education and the New York State Society of Professional Engineers. He has served on the following AIEE committees: Applications to Iron and Steel Production (1930-38); Electric Welding (1934-40); and Edison Medal (1947-52).

S. P. Hunt (AM '03, M '13, Member for Life), manager, Samuel P. Hunt, Engineers, Manchester, N. H., has established a $500,000 charitable trust fund to be administered by the Merchants National Bank, Manchester, and R. A. McIninch, president of the bank, as trustees. The articles establishing the Samuel P. Hunt Foundation direct the trustees to use the income of the trust "for such worthy public, charitible, religious, or educational organizations established under the laws of the United States or any of the states comprising it as the trustees in their sound discretion shall from time to time determine." Mr. Hunt was born in Manchester, February 3, 1874, and graduated from Dartmouth in 1893 and from Massachusetts Institute of Technology in 1895, receiving degrees in electrical and chemical engineering. After his graduation, Mr. Hunt was associated with the American Telephone and Telegraph Company. Over a period of 8 years, he worked for the company in New York, N. Y., Pittsburgh, Pa., Cleveland, Ohio, and Buffalo, N. Y., before becoming an engineer for the Binghampton (N. Y.) Light, Heat and Power Company. He returned to Manchester in 1907 and went to work for the Manchester Traction Light and Power Company and was made assistant general manager. During World War I he went to Washington, D. C., where he was an executive of the national gun factory, afterwards serving as electrical engineering consultant with the Electric Boat Company, Groton, Conn., and the Barstow Company, New York, N. Y. He then attended the Harvard School of Business Administration. Returning to Manchester again in 1925, he became engineer for the Public Service Company of New Hampshire. He retired in 1935, having become chief engineer, but since then has continued as a consultant in engineering.

L. T. Rader (AM '34, F '51), manager of engineering, Control Division, General Electric Company, Schenectady, N. Y., has been appointed general manager of the specialty control department. **H. L. Palmer** (AM '42) has been appointed manager of engineering for the new department. Dr. Rader was born in Alberta, Canada, and was graduated from the University of British Columbia with a bachelor of science degree in electrical engineering and received his master's and doctor's degrees from California Institute of Technology. He joined General Electric in Schenectady, N. Y., and was assigned to the control division where he worked as a design engineer. In 1945 he left to become head of the electrical engineering department at the Illinois Institute of Technology, Chicago. Two years later he returned to General Electric to manage the engineering laboratory of the Control Division. In 1949 he became assistant manager of engineering and was appointed manager of engineering in 1951. Dr. Rader is a member of the Association of Engineering Educators, the Association of University Professors, Sigma Xi, Eta Kappa Nu, and Tau Beta Pi. He has served on the AIEE Committees on Industrial Control Devices (1945–47, 1948–49) and Student Branches (1946–50). Mr. Palmer has served on the Committees on Electronics (1944–50) and Industrial Control (1946–53).

F. L. Snyder (M '46, F '51), vice-president, Westinghouse Electric Corporation, Pittsburgh, Pa., has reassumed management of the firm's Transformer Division at Sharon, Pa. Mr. Snyder previously served as manager of the Transformer Division from 1949 to 1951. A native of Woodbury, Pa., Mr. Snyder was graduated from Gettysburg College with a bachelor of science degree in electrical engineering in 1923. He joined Westinghouse as a design engineer at Sharon in 1925 and advanced through a succession of Transformer Division jobs, until being appointed engineering manager in 1946 and Division manager in 1949. In 1951 he was transferred to Philadelphia, Pa., as manager of the Westinghouse Aviation Gas Turbine Division. In April 1953, Mr. Snyder was elected a vice-president of the company and assigned to the staff of the executive vice-president in charge of defense products. He comes to his new post from this assignment. Mr. Snyder has served on the AIEE Committee on Transformers (1946–52) and as a Liaison Representative on the Standards Committee (1951–53).

J. S. Franklin (AM '40, M '46), development engineer, General Electric Company, Lynn, Mass., has been appointed supervisor of the lighting and rectifier department Photometric Laboratory. Mr. Franklin was awarded a bachelor of science degree at Brown University and a master of science degree at Harvard University. He joined General Electric in 1939. He worked on assignments in the meter and instrument department at West Lynn, Mass., and the induction motor department at Schenectady, N. Y., and served at the 1940 New York World's Fair with the company's House of Magic exhibit. Following a transfer to the power transformer department at Pittsfield, Mass., and a period as instructor in electrical engineering at Brown University, Providence, R. I., he was assigned to the lighting and rectifier department as design Engineer. He joined the Photometric Laboratory in 1951. Mr. Franklin is a member of the Illuminating Engineering Society and the National Society of Professional Engineers.

R. A. Heising (AM '15, F '39), patent engineer, Bell Telephone Laboratories, New York, N. Y., has retired. Dr. Heising entered the employ of the Western Electric Company in July 1914 and began work on radio and carrier communication. He participated to a major extent in all of their early radio work and in engineering the pioneer commercial transoceanic radiotelephone circuits. Dr. Heising's inventions include the constant current modulation system, the grid modulation system, and the rectifier modulation system. He has over 100 United States patents. Dr. Heising transferred to the patent department in 1945 and since has been engaged in patent engineering and other patent work. He is planning to continue his activities as an independent consulting engineer and patent agent. He is serving on the AIEE Board of Examiners (1951–54).

D. C. Ober (AM '16, Member for Life), senior vice-president, The Cleveland (Ohio) Electric Illuminating Company, retired October 11, 1953, after more than 40 years of service. Mr. Ober was born in Chagrin Falls, Ohio, and graduated from Case Institute of Technology with a bachelor of science degree in electrical engineering in 1913. He first became associated with the Illuminating Company in 1912 as a part-time employee while still a student and in 1913 he accepted permanent employment with the company following his graduation. In 1917 he was advanced to assistant in charge of the company's electrical engineering department. He was promoted to executive engineer in 1933, to vice-president in 1944, to executive vice-president in 1945, and to senior vice-president in April 1953. Mr. Ober is a member of the Cleveland Engineering Society.

E. W. Spring (AM '26, M '32), staff assistant on personnel, electrical system, The Detroit (Mich.) Edison Company, has been named assistant director of the Civil Defense Department of the company. **R. E. Greene** (AM '26, M '46), construction engineer, has been named assistant manager of construction; and **R. M. Van Duzer** (M '50), assistant chief engineer of power plants, has been promoted to general superintendent of production. Mr. Spring has served on the AIEE Committees on Research (1939–40) and Student Branches (1949–51, 1952–53); and Mr. Greene has been on the Committee on Power Generation (1935–36).

E. B. Dawson (AM '21, M '28), division manager of application engineering, Elevator Division, Westinghouse Electric Corporation, Jersey City, N. J., has been appointed engineering manager for the division. Mr. Dawson joined the Westinghouse graduate student course in 1919 subsequent to his graduation from Norwich University with a degree in electrical engineering. Until 1928 when he transferred to the then

Westinghouse Elevator Company, Mr. Dawson was an engineer in the company's general engineering department in East Pittsburgh, Pa. Mr. Dawson has served on the AIEE Committee on Electrochemistry and Electrometallurgy (1927–29).

F. E. Leib (M '44), chief electrical engineer, Copperweld Steel Company, Glassport, Pa., has been advanced to manager of sales of the Wire and Cable Division of the company. Mr. Leib also has served previously as assistant manager of sales. **C. C. Sowards** (AM '40), sales engineer, has been named eastern sales manager for the company with headquarters in New York, N. Y.

N. E. Groeneveld Meijer (M '29, F '33), consulting engineer, Bussum, Netherlands, has been appointed director of purchase for the European Council for Nuclear Research, Geneva, Switzerland.

R. J. Wershing (AM '50), engineer, General Electric Company, Philadelphia, Pa., has been appointed to the staff of the Gaseous Diffusion Plant, Paducah, Ky., an atomic energy installation operated by Carbide and Carbon Chemicals Company.

R. H. Barclay (AM '14, F '28, Member fo Life), vice-president in charge of engineering, J. G. White Engineering Corporation, New York, N. Y., has been elected a member of the Institution of Electrical Engineers, Great Britain, and has been selected to serve as honorary secretary in the United States for that institution. (*A complete personal item on Mr. Barclay appeared in EE, Apr '53, p 719.*)

W. H. Clagett, Jr. (AM '34, M '46), chief, Substation and Switchyard Design Unit, United States Bureau of Reclamation, Denver, Colo., has joined Pacific Oerlikon Company, Tacoma, Wash. A native of Colorado, Mr. Clagett attended California Institute of Technology and the University of Idaho, from which he graduated in 1934. After graduation he was with the Washington Water Power Company for 2 years. From 1936 to 1950 he was employed by the Bureau of Reclamation at Grand Coulee Dam in various capacities, which included active charge of high-capacity short-circuit tests on oil circuit breakers during the development of 10,000,000-kva equipment.

G. E. Edgerton (M '29), chairman of the board, Export-Import Bank, Washington, D. C., has been appointed managing director of the bank. Mr. Edgerton's former post was abolished under a reorganization plan.

E. B. Shew (M '48), assistant electrical engineer, Engineering Department, Philadelphia (Pa.) Electric Company, has been appointed assistant development engineer, System Development Division. **F. J. Berger** (AM '27, M '44), plant engineer, Electrical Engineering Division, has been appointed assistant electrical engineer for the division. **F. W. A. Myers** (AM '26), engineer, Engineering Development Section, has been named inside plant engineer in charge of substation and generating station design. Mr. Berger has served on the AIEE Committee on Substations (1948–52).

M. J. DiToro (AM '45, M '45), department head, Advanced Development Laboratory, Federal Telecommunication Laboratories, Inc., Nutley, N. J., has joined Fairchild Guided Missiles Division, Fairchild Engine and Airplane Corporation, Wyandanch, N. Y., as head of electronic development. Dr. DiToro was for a time associate director of the Microwave Research Institute of Brooklyn (N. Y.) Polytechnic Institute. He is a member of the Institute of Radio Engineers, Acoustical Society of America, American Physical Society, Association for Computing Machinery, Eta Kappa Nu, and Sigma Xi.

E. G. S. Maxwell (AM '51), apparatus marketing manager, General Electric Company, Charleston, W. Va., has been appointed manager of apparatus product sales of the Atlantic District with headquarters in Philadelphia, Pa. **W. F. Henn** (AM '41, M '51), manager, Central Station and Transformer Divisions, General Electric Company, Philadelphia, Pa., has been named manager of the company's Philadelphia office. **C. R. Stouch** (AM '49), sales engineer, General Electric Company, Charleston, W. Va., has been appointed manager of the Charleston office. Mr. Henn has served on the AIEE Committees on Management (1952–53) and Technical Program (1948–49).

J. S. Ferguson (AM '45), S and C Electric Company, Chicago, Ill., has been promoted to the position of administrative engineer. Mr. Ferguson joined S and C in 1951. **J. B. Castle** (AM '50), sales engineer, Aluminum Company of America, New Kensington, Pa.; **D. R. Franzmann** (AM '48), district engineer, Northern States Power Company, Chippewa Falls, Wis.; and **J. J. Mikos** (AM '40, M '46), switchgear engineer, Westinghouse Electric Company, East Pittsburgh, Pa., have joined the company. Mr. Castle will be an application engineer; Mr. Franzmann, a sales engineer; and Mr. Mikos will be in charge of final design and engineering of new products.

O. B. Falls, Jr. (AM '39, M '45), central station application engineer, General Electric Company, Seattle, Wash., has been appointed manager of electric utility sales, with headquarters at Schenectady, N. Y.

Arthur Splittberger (AM '51), manager, Products Department, New England District, General Electric Company, Boston, Mass., has been named manager of apparatus and component products sales for the New England District.

Robert Harrington (AFFIL '52), engineer, General Electric Company, Lynn, Mass., has joined Orangeburg (N. Y.) Manufacturing Company, Inc., as director, New Products Development. Mr. Harrington is a member of the American Chemical Society and the Society of Plastics Engineers.

R. A. Osborne (AM '47), manager, Rochester (N. Y.) office, General Electric Company, has been named manager of sales of the Empire District. **H. C. Lindberg** (AM '35, M '47), engineer, Buffalo (N. Y.) office, has been appointed Empire District manager of engineering. **W. F. Rauber** (M '45), sales manager, Switchgear Division, Philadelphia, Pa., has been appointed manager of the Buffalo office; and **J. D. Hershey** (AM '40), sales engineer, Syracuse, N. Y., has been named manager of the Rochester office.

M. M. Ulgur (AM '49), professor of electrical engineering, Technical University of Istanbul, Turkey, has been appointed dean of electrical engineering faculty. Dean Ulgur was born in Istanbul, December 23, 1917. He received the degree of master of science in electrical engineering in 1941 from the Technical University of Istanbul. His association with the university in a teaching capacity began immediately after his graduation. He received the degree of docent in 1946 and was appointed a professor in 1952. From 1949 to 1951, Dean Ulgur was associated with the General Electric Company in the United States.

Oliver Ramsaur (M '46), assistant communications engineer, Pennsylvania Power and Light Company, Allentown, has been appointed vice-president in charge of engineering and construction. Following his graduation from North Carolina State College in 1920, he joined the Westinghouse Electric and Manufacturing Company (now the Westinghouse Electric Corporation), East Pittsburgh, Pa., and in 1921 he entered the employ of the Carolina Power and Light Company as draftsman-engineer. He joined Pennsylvania Power and Light in 1923 as a checker in the electrical drafting room, becoming engineer in the electrical division in 1925. A series of subsequent promotions made him assistant electrical engineer in 1930, engineer, electrical section, in 1937, control equipment engineer in 1942, electrical planning engineer in 1946, and development engineer in 1950. He was named assistant communications engineer in July of this year. Mr. Ramsaur is a registered professional engineer in Pennsylvania.

V. M. Graham (M '47), director of technical relations, Sylvania Electric Products, Inc., New York, N. Y., has been elected a vice-president and member of the Executive Committee of the United States National Committee of the International Electrotechnical Commission, the international standardizing organization in the electrical and electronic fields. Mr. Graham is chairman of the Communications and Electronics Section, Electrical Standards Board, of the Joint Electron Tube Engineering Council of the Radio-Electronics-Television Manufacturers Association (RETMA) and the National Electrical Manufacturers Association, and associate director of the RETMA engineering department.

C. H. Lang (AM '43), vice-president of public relations, General Electric Company, Schenectady, N. Y., has been awarded the honorary American Farmer degree by the Future Farmers of America for his nearly 30 years of support of farming programs. Mr. Lang is chairman of the organization's sponsors' committee.

W. E. Shoupp (M '48), director of development for the Atomic Power Division, Westinghouse Electric Corporation, Pittsburgh, Pa., has been appointed assistant division manager in charge of development. A graduate of Miami University in 1931 with the degree of bachelor of arts in physics, Dr. Shoupp received a master of arts degree at the University of Illinois in 1933 and a doctor of philosophy degree in 1937. He joined Westinghouse as a Research Fellow in 1938 and has been with the Atomic Power Division since 1949. Dr. Shoupp recently was awarded the Westinghouse Order of Merit for his work on the first submarine atomic power plant. He served on the AIEE Committee on Nucleonics (1949–53).

R. H. Hose (AM '51), associate, Henry Dreyfuss, New York, N. Y., and a practicing industrial designer since 1939, recently was elected president of the Society of Industrial Designers. He is a registered architect in the state of New Jersey and a member of The American Society of Mechanical Engineers.

R. C. Wilson (AM '47) manager—product planning, General Electric Company, Plainville, Conn., has been named manager—engineering of the newly established distribution assemblies department. Mr. Wilson, a graduate of the University of California, joined General Electric in 1946 as a student in the test engineering program. He joined the former Trumbull Electric Department in 1948, and has held the positions of sales manager of the Norwood plant, and sales engineering manager of the department's central region.

M. M. Koch (AM '20, M '26), vice-president in charge of electric operations, Public Service Company of Colorado, Denver, has been elected president of the Rocky Mountain Electrical League. Mr. Koch was Colorado vice-president of the League for 1952–53.

Roland Whitehurst (AM '20, F '43), vice-president and director, The Electric Storage Battery Company, Philadelphia, Pa., will assume additional duties as general manager of the industrial products division. Mr. Whitehurst entered the employ of The Electric Storage Battery Company in 1908 as an office boy in the New York branch. Subsequently he served in various sales capacities in New York, Washington, D. C., and Philadelphia, and in 1948 was appointed vice-president in charge of sales. He was elected to the board of directors in 1951. Mr. Whitehurst is a past chairman of the AIEE Washington Section and has served on the Board of Examiners (1950–52).

OBITUARY • • • •

Herbert Eugene Ives (F '29), retired, Bell Telephone Laboratories, Inc., New York, N. Y., died November 13, 1953. Dr. Ives' research had resulted in the first public demonstration of television in 1927. Generally considered one of the world's leading electron-optical scientists, Dr. Ives had developed, among other things, 3-dimensional pictures, an artificial eye for use in photometry, a method for the description of colors in precise numerical terms, and the first practical lamp for the production of artificial daylight. Dr. Ives was born in Philadelphia, Pa., July 31, 1882, and studied at the University of Pennsylvania and Johns Hopkins University, receiving the degree of doctor of philosophy from the latter institution in 1908. He was associated with the National Bureau of Standards and later with several private research concerns. During World War I he received a captain's commission in the aviation section of the Signal Corps, where he did pioneer work in aerial photography. After his Army service he joined Bell Telephone Laboratories as a member of the research and technical staff. At the time of his retirement in 1947 he was director of electro-optical research. Dr. Ives was a member of many scientific societies and a former vice-president of the American Association for the Advancement of Science, and the Illuminating Engineering Society, and a former president of the Optical Society of America. Among the honors and medals he received were the Longstreth Medal from the Franklin Institute, the John Scott Medal of the Optical Society of America, and the Medal for Merit, the highest civilian award of the United States government for his work in World War II on facilitating military operations at night. Dr. Ives had served on the AIEE Committee on the Production and Application of Light (1932–34) and the Board of Examiners (1951–52).

Frank E. Brumfield (AM '45), building and equipment engineer, Ohio Bell Telephone Company, Cleveland, died October 27, 1953. Mr. Brumfield was born in Pittsboro, Ind., August 29, 1891. Before coming to Ohio Bell in 1921 he had been associated with the Ohio State Telephone Company, Alliance, and before that had been employed by several independent telephone companies in Indiana and Michigan. After joining Ohio Bell, Mr. Brumfield had served as central office equipment maintenance engineer, maintenance and circuit engineer, dial equipment engineer, inventory and cost engineer, and building and equipment engineer. He was a member of the Cleveland Engineering Society and the Telephone Pioneers of America.

William Curzon Seymour (AM '49), operating statistics supervisor, Pennsylvania Power and Light Company, Hazleton, died November 8, 1953. Mr. Seymour was born in Baltimore, Md., February 2, 1902. He joined Pennsylvania Power and Light in 1930 in Wilkes-Barre and was transferred to Hazleton in 1938 as voltage control engineer. He had been in his present position since 1945. Mr. Seymour was secretary-treasurer of the Lehigh Valley Section of the AIEE.

MEMBERSHIP • • •

Recommended for Transfer

The Board of Examiners at its meeting of November 19, 1953, recommended the following members for transfer to the grade of membership indicated. Any objections to these transfers should be filed at once with the Secretary of the Institute. A statement of valid reasons for such objections, signed by a member, must be furnished and will be treated as confidential.

To Grade of Member

Allen, H. A., district engineer, Southern Bell Tel. & Tel. Co., Greensboro, N. C.
Arthur, J. M., senior development engineer, Duquesne Light Co., Pittsburgh, Pa.
Baker, R. S., electrical engineer, Mine Safety Appliances Co., Callery, Pa.
Bergseth, F. R., associate professor of electrical engineering, University of Washington, Seattle, Wash.
Boone, E. M., professor of electrical engineering, Ohio State University, Columbus, Ohio
Boykin, E. M., director, field service div., Hughes Aircraft Co., Culver City, Calif.
Carson, N. R., chief electrical engineer, Erik Floor & Associates, Inc., Chicago, Ill.
Chard, R. J., electrical job engineer, Bechtel Corp., San Francisco, Calif.
Charlton, A. A., senior design engineer, Duquesne Light Co., Pittsburgh, Pa.
Clark, W. A., engineer, American Tel. & Tel. Co., New York, N. Y.
Cooley, C. W., senior engineer, Michigan Bell Telephone Co., Detroit, Mich.
Crowder, J. A., underground electrical engineer, Knoxville Utilities Board, Knoxville, Tenn.
Frost, H. J., engineer, Ohio Bell Telephone Co., Cleveland, Ohio
Gelbke, A. M., electrical engineer, Ebasco Services, Inc., Mexico, Federal District, Mexico
Hecht, H., engineering section head, servo system development, Sperry Gyroscope Co., Great Neck, N. Y.
Hensler, J. F., sales & service engineer, The Electric Storage Battery Co., Pittsburgh, Pa.
Inglis, W. G., engineer, Oklahoma Gas & Electric Co., Fort Smith, Ark.
Kelsey, P. C., electrical engineer, Appalachian Electric Power Co., Huntington, W. Va.
Lusk, R. J., advisory engineer, air arm div., Westinghouse Electric Corp., Baltimore, Md.
Misra, R. P., project engineer, Philco Corp., Lansdale, Pa.
Moore, J. H., chief engineer, Northwestern Bell Telephone Co., Minneapolis, Minn.
Murray, R. L., Engineer, Alabama Power Co., Birmingham, Ala.
Ofverholm, H., director, STAL Turbine Co., Finspong, Sweden
Peters, P. M., electrical engineer, George L. Nankervis Co., Detroit, Mich.
Richards, E. E., chief electrical engineer, Marathon Electric Mfg. Co., Erie, Pa.
Sellers, A. H., engineer, Philadelphia Electric Co., Philadelphia, Pa.
Slind, M. T., engineer, General Electric Co., Richland, Wash.
Sprankle, C. H., staff assistant, American Tel. & Tel. Co., Kansas City, Mo.
Thibaut, A. A., Jr., electrical engineer, Knoxville Utilities Board, Knoxville, Tenn.
Wood, C. L., plant manager, Willys Motors, Kaiser Electronics Div., Arlington, Va.
Yarbrough, R. D., division plant extensions engineer, Southern Bell Tel. & Tel. Co., Jackson, Miss.

31 to grade of Member

Applications for Election

Applications for admission or re-election to Institute membership, in the grade of Fellow and Member, have been received from the following candidates, and any member objecting to election should supply a signed statement to the Secretary before January 25, 1954, or March 25, 1954, if the applicant resides outside of the United States, Canada, or Mexico.

To Grade of Member

Clapp, W. J., Florida Power Corp., St. Petersburg, Fla.
Dandelake, J., Miller Elec. Co. of Fla., Miller Elec. Co. of S. C., & Jacksonville Metal & Plastics Co., Jacksonville, Fla.
Wheeler, B. F., RCA Victor Div. of RCA, Camden, N. J.

3 to grade of Member

OF CURRENT INTEREST

RCA Demonstrates Magnetic Tape Recording of Color and Black-and-White TV Pictures

Recording of television pictures on magnetic tape in color and in black-and-white was demonstrated publicly for the first time on December 1, 1953, by the Radio Corporation of America (RCA) at its Princeton, N. J., laboratories in a preview of new techniques that will simplify the entire art of making pictures in motion.

Brigadier General David Sarnoff, chairman of the board of RCA, said that this new method of recording sight is similar in basic respects to tape recording of sound. He described the achievement as the first major step into an era of "electronic photography," in which motion pictures in color or black-and-white will be produced quickly and economically, without any photographic development or processing.

In the demonstration, a color television program originating in National Broadcasting Company studios in Radio City, New York, N. Y., was beamed by radio microwave across the 45-mile span to RCA's David Sarnoff Research Center at Princeton, N. J.

This program was seen as it arrived. At the same instant, the tape recording system recorded the television picture on a strip of magnetically coated plastic tape as thin as paper, and 1/2 inch in width. During part of this transmission, both the live program from the microwave radio relay and an immediate playback of the magnetic tape recording were shown. As soon as the tape reel was rewound, it was played back and the recorded television pictures appeared on two RCA color television receivers.

In the first part of the demonstration, previously recorded magnetic tapes were run through the equipment. This phase included the reproduction of both black-and-white television pictures and color television pictures that had been beamed over the same New York–to–Princeton microwave link at an earlier date.

The same apparatus handled both the recording and playback of the tape for both the color and black-and-white tests. This relatively compact experimental equipment was developed by a 7-man team of RCA research engineers consisting of Dr. Harry F. Olson and William D. Houghton, who head the development program, and Maurice Artzt, J. T. Fischer, A. R. Morgan, J. G. Woodward, and Joseph Zenel.

RCA's method of video recording is similar, in basic respects, to the techniques used to record speech and music with present-day magnetic tape sound equipment. Electric signals are impressed through a recording head onto the magnetically treated surface of a plastic tape. As the tape is drawn across the recording head, the head continuously changes the magnetic polarity of the magnetic oxide particles on the tape so that they become a compact code of the original signal. For playback, the tape is drawn across the same, or a similar head. The magnetic "shorthand" on the tape causes an alternating current to flow in the windings around the reproducing head. The reproduced current closely duplicates the original signal.

Although the principles are similar, the engineering problems are not; audio recording is today an easy task compared with video recording. The reason is that audio signals are in the range of 20 to 20,000 cycles, while video signals range up to 4 megacycles. And color television signals, as now formulated, must carry at least twice as much pictorial information as black-and-white; also video tape must carry the associated sound signals.

Among technical video tape problems already solved by RCA, or approaching solution, are the following:

High-Frequency Recording Heads. RCA research has resulted in specially developed recording and reproducing heads which respond to frequencies many times above the cut-off point for the recording heads used in sound recording on magnetic tape. This means that the speed of the tape across the head has been brought within manageable limits. The television equipment demonstrated had a tape speed of 30 feet per second. Advanced equipment now under construction will move the tape at a lower speed, and with time, further reductions of tape speed appear likely.

Future Meetings of Other Societies

American Physical Society. Annual Meeting. January 28–30, 1954, Hotel New Yorker, New York, N. Y.

Association of Iron and Steel Engineers. West Coast Meeting. February 15–17, 1954, Hotel Statler, Los Angeles, Calif.

Audio Engineering Society. 1954 Audio Fair. February 4–6, 1954, Alexandria Hotel, Los Angeles, Calif.

Conference on Marine Corrosion Problems. February 8–9, 1954, University of California, Berkeley, Calif.

Conference on Operations Research in Production and Inventory Control. January 20–22, 1954, Case Institute of Technology, Cleveland, Ohio

High-Speed Computer Conference. January 28–30, 1954, Louisiana State University, Baton Rouge, La.

Industrial Engineering Institute. 6th Annual Conference. January 29–30, 1954, University of California, Berkeley, Calif., and February 1–2, 1954, University of California, Los Angeles, Calif.

Institute of Radio Engineers. 6th Annual Conference and Electronics Show. February 4–6, 1954, Hotel Tulsa, Tulsa, Okla.

Institute of the Aeronautical Sciences. 22d Annual Meeting. January 25–29, 1954, Hotel Astor, New York, N. Y.

Instrument Society of America. 5th Annual Southeastern Symposium on Industrial Instrumentation. February 1–3, 1954, University of Florida, Gainesville, Fla.

Instrument Society of America. 9th Annual Regional Conference. February 4, 1954, Hotel Statler, New York, N. Y.

National Association of Purchasing Agents, Public Utility Buyers' Group. Mid-Winter Conference. February 15–16, 1954, Lord Baltimore Hotel, Baltimore, Md.

National Rural Electric Co-operative Association. National Convention. January 11–14, 1954, Miami, Fla.

Plant Maintenance and Engineering Conference and Show. January 25–28, 1954, Conrad Hilton Hotel and International Amphitheatre, Chicago, Ill.

Society of Automotive Engineers. Annual Meeting. January 11–15, 1954, The Sheraton-Cadillac Hotel and Hotel Statler, Detroit, Mich.

Society of Plastics Engineers. 10th Annual Technical Conference. January 27–29, 1954, Royal York Hotel, Toronto, Ontario, Canada

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TAPE TRANSPORT MECHANISM

RCA research engineer Joseph Zenel displays an experimental recording head unit which has been especially designed to respond to the high frequencies of television signals

Size of Magnetic Tape Reels. The magnetic tape reels of the present laboratory equipment are 17 inches in diameter and will record 4 minutes of a television program. RCA is working now for a reel 19 inches in diameter which will carry a 15-minute program.

Electronic Amplifying and Equalizing Circuits. Recording and reproducing amplifiers have been designed to handle the signal inputs and outputs. These take into account and compensate for the characteristics of the heads and the magnetic tape materials when recording the very wide bands of frequencies used in television. Further development is in progress to obtain even better response characteristics.

Constant-Speed Tape Transport Mechanism. Since even small variations in the speed of

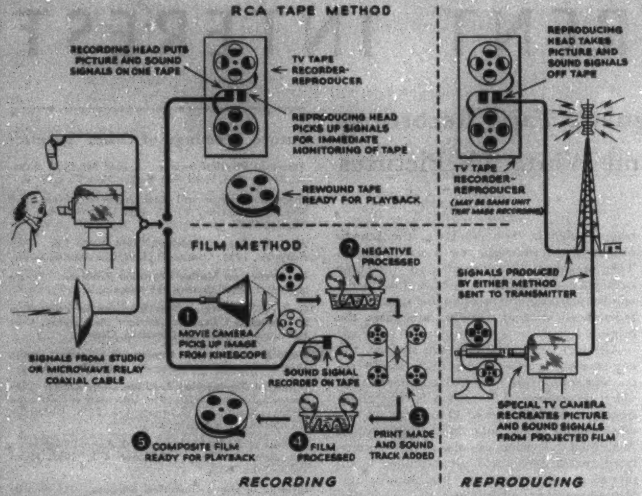
RCA TAPE METHOD
RECORDING HEAD PUTS PICTURE AND SOUND SIGNALS ON ONE TAPE
TV TAPE RECORDER-REPRODUCER
REPRODUCING HEAD PICKS UP SIGNALS FOR IMMEDIATE MONITORING OF TAPE
REWOUND TAPE READY FOR PLAYBACK
FILM METHOD
① MOVIE CAMERA PICKS UP IMAGE FROM KINESCOPE
② NEGATIVE PROCESSED
SOUND SIGNAL RECORDED ON TAPE
③ PRINT MADE AND SOUND TRACK ADDED
④ FILM PROCESSED
⑤ COMPOSITE FILM READY FOR PLAYBACK
SIGNALS FROM STUDIO OR MICROWAVE RELAY COAXIAL CABLE
RECORDING
REPRODUCING HEAD TAKES PICTURE AND SOUND SIGNALS OFF TAPE
TV TAPE RECORDER-REPRODUCER (MAY BE SAME UNIT THAT MADE RECORDING)
SIGNALS PRODUCED BY EITHER METHOD SENT TO TRANSMITTER
SPECIAL TV CAMERA RECREATES PICTURE AND SOUND SIGNALS FROM PROJECTED FILM
REPRODUCING

Diagram shows steps in recording and reproducing a television program by RCA video tape method as compared to typical film method used in a broadcasting station today

the tape and in the pressure at which it bears on the head can create noticeable effects in the picture, it has been necessary to devise precision apparatus (servomechanisms) to control accurately the speed of the tape at the recording and reproducing points. The laboratory video tape equipment controls these many times more accurately than is necessary in magnetic tape recorders for sound. Even greater precision in regulating speed and pressure appears possible through research which is now under way.

Assignment of Tape Channels. For video tape recording of color television with the RCA system, five parallel channels are recorded on a single magnetic tape 1/2 inch in width. There is one recorded channel for each of the primary color signals (red, green, and blue), for the synchronizing signal, and for the sound signal. For black-and-white recording the tape carries two recorded channels, one for the video signal and the synchronizing signal, and one for the sound signal. For black-and-white television, a 1/4-inch-wide tape would suffice.

In the demonstration of color television recording on magnetic tape, the five recorded channels were obtained from the output of a color television receiver. In reproducing from the recordings, the tape supplied the three primary color signals direct to the three electron guns of an RCA tricolor kinescope, the signals needed to synchronize the scanning, and the signal which carried the sound.

To rebroadcast a color television program from a tape recording, it is necessary to combine the three primary color signals with the synchronizing signal to form a composite signal to send to the transmitter. While this operation is not yet ready for demonstration, it is the subject of current development that will provide the necessary apparatus to produce this result.

Outlining the need for tape recording techniques, Dr. E. W. Engstrom, vice-president in charge of RCA Laboratories Division, explained the complications involved in conventional kinescope recording of television pictures.

"When a television program is recorded by kinescope recording methods," he said, "the pictures pass from the television camera through most of the television system to be reproduced on a small kinescope (picture tube). A special motion picture camera then photographs the program on motion picture film. The film must be chemically processed and, usually, a print made before the pictures can be reproduced. The reproduction requires another installation in which a television camera tube picks up the scene from a motion picture projector for rebroadcast.

"The current kinescope recording process is a round-about and costly approach. It is time-consuming, with film processing time running to several hours in most cases. And the quality may be limited, since the pictures must encounter all the hazards of both the television system and the photographic process. In going from the electric signals of the camera to the signals for rebroadcast by a television transmitter, kinescope recording requires four separate intermediate pictures to be formed, two by television and two photographically. There is no fundamental need for these intermediate steps.

"Magnetic tape recording, in contrast, stores the electric signals directly as they come from the television camera. No processing, electronic or photographic, is necessary before the tape is played back. A single compact piece of equipment, which handles both recording and reproduction, will do the job of two complex installations needed with photographic methods."

Comparative estimates of operating costs (which include payroll, cost of tape or film, and amortization of equipment) are highly favorable to tape methods. Although magnetic tape today costs more per minute of program time than 35-millimeter color film, the fact that tape needs no processing before playback compensates for the expense of raw tape. Engineers pointed out that what makes the savings on tape so great is the fact that the program can be electronically "wiped off" and the tape reused; in normal operations it would be reused many times.

Recording black-and-white programs on film is estimated to be at least five times as costly as it would be on 1/4-inch magnetic tape, assuming that the tape would be reused many times. In making copies for distribution to television stations, a half-hour program could be taped for less than $15 per copy, provided the tape is reused many times. (These figures, of course, refer only to the cost of producing the recorded tape, and not to the cost of the program.)

Even greater economies are estimated for making the original *tape* recording of color television programs, which under normal operating circumstances could be handled for only 5 per cent of the cost entailed in color *film* recording. In making copies on tape that is to be used over and over again, a tape recording of a half-hour color program would cost roughly $20.

World's Most Powerful Radio Transmitter Is Dedicated by the Navy and RCA

The world's most powerful radio transmitter went into operation recently at Jim Creek Valley, Wash., in the Cascade mountains when for the first time in the nation's history the United States Navy was able to flash instantaneously a wireless message around the world directly to all of its ships and naval units.

The message, from Admiral Robert B. Carney, Chief of Naval Operations, was tapped out in the wireless code by Brigadier General David Sarnoff, chairman of the board of the Radio Corporation of America (RCA). It was sent to naval units on land, in the air, and on and under the surface of the seas.

"With this first message, we forge another link between you and your homeland," Admiral Carney said, as the Navy, in cooperation with RCA, dedicated the 1,200,000-watt radio transmitter. "With it, we build a new security channel from America to the naval units which form its outer ramparts of defense."

The giant radio station, a 6-year project of the Navy and RCA, was constructed to provide the Navy, for the first time, with instantaneous communications with fleet units everywhere. Its output is more than twice that of any existing military transmitter and 22 times greater than any commercial station. Within minutes of the first transmission, acknowledgments of receipt were relayed back from the flagships of the Atlantic and Pacific fleets, from naval aircraft, from Arctic outposts, and from submarines beneath the surface. As they arrived, their location was plotted on a world map to illustrate the transmitter's globe-girdling range.

View through steel framework of 200-foot summit ridge tower of transmitter building in valley

Among the engineering achievements in the design of the new Navy equipment the following were cited:

(a) A conservatively rated 1,200,000-watt output from four superpower electron tubes designed specifically for this type of service. This represents a four-fold advance over older equipments which use eight tubes to develop 500,000 watts.

(b) Microsecond fault protection developed specifically for this Navy equipment. This electronic device relieves overload faults in the superpower amplifier tubes in the fantastically short time of seven millionths of a second and prevents the build up of currents that could damage the tubes.

(c) Elimination of tuning controls in all low-power stages through the penultimate amplifier. Tuning adjustments are confined to remote push-button control of the antenna and power amplifier tuning. This is accomplished by special broad-band amplifiers developed by RCA and widely used in the company's standard broadcast transmitters.

(d) Simplification of complex control functions such as the mimic bus controls on the operator's supervisory console which tell at a glance which units are in use and which are in an idle or test status.

(e) Development of a variable-frequency oscillator having a frequency stability of 0.001 per cent. Advanced development based upon experience with binary computer circuitry resulted in this extremely stable frequency source which may be set to any frequency in the 14.5- to 35-kc very-low-frequency band.

(f) Design of the highly efficient catenary-type antenna system. The ten catenary spans, representing the largest antenna ever erected, were designed by experienced RCA Communications Company engineers.

Six 200-foot towers were constructed on 3,200-foot Wheeler Mountain on the north, and six more on 3,000-foot Blue Mountain on the south. Between them, in the valley, are the cables—the ten catenary spans of the antenna—ranging in size from 5,640 to 8,700 feet in length. On the valley floor are 23 other towers, some of them 145 feet tall, supporting the down leads, feed bus, and the counter-weights that keep the down leads in tension.

View from transmitter building, along antenna lead-in trunk, shows 145-foot bus tower halfway up mountain, one of 13 which support transmission line. "Doughnuts" are corona shields which guard trunk from corona discharge

The megawatt transmitter has been designed around the special RCA type *5831*—500-kw high vacuum triode. Each of the two power amplifiers employs three *5831*'s, two in the push-pull circuit with the third available as a spare. The tubes are cylindrical, with disk electrode connections. They are about 10 inches in diameter and $38^{3}/_{4}$ inches in length, and weigh 135 pounds. The anode, grid supports, and cathode beam former are water cooled. The 6-volt filament structure of thoriated tungsten will require approximately 13-kw heating power. Each tube requires about 500 watts grid drive for 285-watt output at 80-per-cent plate efficiency. Plate voltage is 11.5 kv. The four operating tubes in both power amplifiers will deliver 1,000 kw to the antenna system.

The outdoor antenna catenary spans are designed as standing rigging to withstand 1/2-inch radial ice in a 65-mile-per-hour gale. The area between the 12 200-foot support towers encompasses 725 acres of which 435 acres are covered by active radiating elements of the antenna.

The intense electromagnetic field around the transmitter necessitates an elaborate grounding system for the entire structure, including copper shielding and a ground screen around the building. More than 200 miles of copper wire went into this radial system of buried ground conductors.

The watershed of Jim Creek and Twin Lakes supplies the water for cooling the equipment and for fire-fighting purposes. Prime electric power, about 2,000 kw necessary to operate the equipment and other facilities, is provided over a 12-mile 110-kv spur line which connects to the Baker River system near Arlington. A substation within the reservation transforms the incoming high voltage to 4,160 volts, 3 phase, and lower voltages for transmitter and other station use. A projected diesel-electric plant will provide emergency power.

Radio Engineers Hold Meeting on Vehicular Communications

The Boston section of the Institute of Radio Engineers (IRE) was host to the National Professional Group on Vehicular Communications, IRE, in a convention, November 12–13, 1953, at the Hotel Somerset, Boston, Mass. This was the fourth annual meeting of the Professional Group, made up of engineers concerned with 2-way mobile radio communication.

According to Waldo A. Shipman, chairman of the national group, membership is composed of manufacturers and users of 2-way radio gear, with papers given by both at the annual meetings. This provides opportunity for interchange of information on new equipment developments and operating methods that is mutually beneficial.

It was pointed out that 2-way radio usage has experienced a phenomenal growth since 1947, and is now responsible for a major American industry. Well over 600,000 transmitter receivers are installed in automobiles and trucks used by commercial industry, municipal agencies, public utilities, and telephone companies, in addition to military appliations. Such unprecedented acceptance of 2-way radio as a tool for increasing operating efficiency has resulted in "channel-crowding" in many areas, which causes mutual interference between users of the equipment. Accordingly, most papers at the current meeting were devoted to tentative solutions to this problem.

A highlight of the meeting was an address by the Honorable Donald S. Leonard, commissioner of the Detroit (Mich.) Police Department. The commissioner discounted warnings of an imminent all-time peak crime-wave, saying that such a phenomena could occur only if law-enforcement agencies were to be handicapped by the absence of 2-way radio communication. He cited the rapidly rising crime rate during the 1920's as the worst in our history. This reached terrifying proportions in 1929, when Detroit received the first municipal broadcast license for its police department. (The station call-letters were, appropriately enough, *KOP.*) A startling reduction in the Detroit crime rate resulted, and other cities followed the lead immediately. The crime wave was halted. Commissioner Leonard termed 2-way radio as "the greatest single weapon" of the police.

The meeting was addressed at its banquet by Saville R. Davis, American News Editor of the *Christian Science Monitor,* who talked on "Engineers and Government: A Study in Communications."

Beverley Dudley is chairman of the IRE Boston section and R. W. Lewis is chairman of the Boston Professional Group Chapter. P. R. Kendall headed the annual meeting committee.

EE Laboratory Donated to Carnegie Tech by Westinghouse

An electrical engineering laboratory, the only one of its kind existing in an educational institution in the world, has been donated to Carnegie Institute of Technology by Westinghouse Electric Corporation.

Valued at approximately $100,000, the new installation is expected to stimulate student interest in power engineering which has been somewhat overshadowed by the swift rise of developments in the communications field.

The laboratory will be used for education and research dealing with the detailed and advanced study of electric power systems and advanced study of a-c generators. The facilities of the laboratory will provide for advanced instruction in rotating machinery for senior undergraduate students and work in power system stability for graduate students. This laboratory is the largest single facility ever donated by an industry to an educational institution.

View of control panel in new $100,000 electrical engineering laboratory at Carnegie Institute of Technology. Dr. H. M. McConnell, assistant professor of electrical engineering at Carnegie and supervisor of the laboratory, prepares to put one of the large a-c generator units into action

Formerly a part of the research and development facilities of the East Pittsburgh, Pa., manufacturing plant of Westinghouse Electric Corporation, the new installation was used there in research contributing to the present expansion and interconnection of electric systems in the United States. Although Westinghouse still may use the equipment in the solution of possible future problems, all data gathered in the course of research at Carnegie Institute of Technology will be made available to the electrical industry through the usual channels.

Because of the new equipment, the school will be able to set up a miniature power system closely duplicating actual transmission lines and interconnected generator stations. Specifically, the laboratory was designed to solve problems dealing with voltage regulators, transient characteristics, exciter characteristics within stability limits, and subtransient reactances. It is in the latter field that most research probably will be done.

The laboratory area is enclosed by a safety fence and an accompanying soundproofed briefing room. The equipment consists of two 100-kva a-c generators, each driven by separate 150-horsepower d-c motors, together with 72 reactors, each rated at 1 ohm, 100 amperes, 60 cycles. These units are accompanied by the necessary circuit breakers, high- and low-voltage switchgear, transformer banks, and metering facilities.

The new installation will be under the direction of Dr. E. M. Williams, head of the electrical engineering department, and will be supervised by Dr. H. M. McConnell, assistant professor of electrical engineering.

Lindbergh Named Recipient of 1953 Daniel Guggenheim Award

The selection of Charles Augustus Lindbergh as the recipient of the Daniel Guggenheim Award for 1953 has been announced jointly by The American Society of Mechanical Engineers, the Society of Automotive Engineers, and the Institute of the Aeronautical Sciences. Presentation of the award will be made by Harry Guggenheim at the Honors Night Dinner of the Institute of the Aeronautical Sciences on January 25, 1954, at the Hotel Astor in New York, N. Y.

Lindbergh was selected as this year's medalist "for pioneering achievements in flight and air navigation." His achievements have extended over the past quarter of a century. His solo nonstop New York–to–Paris flight in 1927 touched off a chain of events that have changed the course of history. Since then, he has been active in mapping out domestic and overseas routes for overseas air lines, has made extensive contributions to the American aircraft manufacturing industry, and during and subsequent to World War II has served on numerous technical missions as Advisor to the United States Air Force and United States Navy.

The Daniel Guggenheim Medal was created as an international award to honor those persons who have made notable achievements in the advancement of aeronautics. It was provided for in 1928 by a gift from the Daniel Guggenheim Fund for the Promotion of Aeronautics. The award has been presented annually since 1929, the first recipient being the late Orville Wright who was cited "for design and construction, with his brother now deceased, of the first successful engine-propelled airplane."

Charles Lindbergh is a Fellow and a Founder Member of the Institute of Aeronautical Sciences.

High-Speed Computer Conference to Be Held at LSU in January

A High-Speed Computer Conference will be held on the campus of the Louisiana State University, January 28–30, 1954, this being the first time that a conference of this kind has been held in the South. This conference is being sponsored by the university in cooperation with a number of business, accounting, research, and engineering organizations interested in high-speed computers. The purpose of the conference is to discuss the uses and applications of high-speed computers in business office procedures, statistical operations, and scientific and technical analyses.

On exhibit during the 3-day meeting will be electronic and other high-speed computing devices and equipment, points out Dr. Leon Megginson, chairman of the conference. Experienced operators will be on hand to demonstrate the intricate mechanisms. Scheduled on the program will be speakers nationally prominent in the field of high-speed machinery.

It is felt that a conference of this nature will be of immeasurable value to both business and research workers who have need for such machines in handling business and statistical data and in the rapid solution of complex technical problems. Early registration will be appreciated. A registration fee will be charged.

Those desiring more detailed information should write directly to Dr. Megginson, care of Louisiana State University, Baton Rouge, La.

Adaptable Electronic Chassis for Components Developed by NBS

In response to the need for a components' chassis that would lend itself to varied and changing electronic designs, the National Bureau of Standards (NBS) has developed a widely adaptable chassis that is both economical and convenient. The design of the new chassis includes a rectangular frame made of 3/8-inch by 1/16-inch steel angle and sets of flat plates that are fitted to the frame with screws. The frames vary in size so that chassis may be made up as small 3- by 4-inch boxes, or 3- by 13- by 16-inch models, or even whole networks of different-sized chassis.

Conventional electronic chassis, normally built with five sides, often impose restrictions on the movement of tools used to drill and punch the required holes and recesses. After the components have been installed in the chassis and the experimental circuit tested, either a relatively expensive piece of equipment must be thrown away or valuable storage space must be used for an item that is only potentially useful. Even during the development stages of the circuit, the design of conventional chassis does not lend itself

Several adaptable electronic chassis designed by NBS. The 3- by 4- by 4-inch chassis (foreground) illustrates the freedom of accessibility to components in even the smallest model. Other circuits may be added easily by mounting the components on a plate of the proper size and screwing the plate to the frame. For special requirements, plates of a nonconducting material may be used. The chassis (rear) are, from the left, 13- by 16- by 4-inch, 8- by 13- by 4-inch, and 3- by 4- by 4-inch models

to exposure of the circuit wiring and tube sockets to facilitate probing and rewiring. Sometimes a great simplification is possible in the construction of equipment if several "breadboard" models can be pieced together, but this is a difficult task requiring complex mechanical structures if the components are mounted in standard chassis.

The chassis developed by NBS are produced in four standard sizes, all 3 inches high: 16 by 13 inches, 13 by 8 inches, 8 by 4 inches, and 4 by 4 inches. Flat cover plates are drilled with holes that match screw-holes in the frames. The dimensions of the chassis and plates were chosen so that the long side of each chassis matches the short side of the next larger size. When desired, any of the six side plates may be left blank or discarded entirely; thus, ventilation may be obtained for circuits requiring air circulation. No restrictions are placed on the kind of material from which the flat plates are made. Consequently, it is possible to eliminate much of the component insulation required when using all-metal chassis.

In developing a circuit, the components may be assembled in "breadboard" style on one or more flat plates before final mounting on a suitable frame. This procedure facilitates and simplifies the often laborious details of drilling, punching, deburring, or nibbling. Once the units have been mounted in the plates, they may be screwed onto the frames with all the wiring and tube sockets on the open (outer) side of the plate exposed to the probing of the test equipment. If the design and craftsmanship permit, these same plates may be reversed later; the wiring then will be protected, the tubes will be accessible for replacement, and the completed unit is ready for actual operation.

If a component is a prototype or has become obsolete, only the plate containing the circuit in question need be removed from the frame and replaced with the improved circuit. The discarded plate then can be stripped of the easily removable components and stored in a shallow drawer or cabinet until a similarly patterned plate is needed again. If desired, whole clusters of these versatile chassis may be assembled around or on top of a larger chassis—the frames are sufficiently standardized to permit this. In addition, the spacing between the holes permits the mounting of commercially available Bakelite terminal strips.

Waste Heat From Atomic Reactors to Be Used in Heating Buildings

The General Electric Company disclosed recently that large quantities of waste heat developed in atomic reactors at the Hanford plutonium-producing plant at Richland, Wash., shortly will be used for the first time in the United States for heating buildings.

This practical industrial use of the excess heat will be achieved by indirectly using water carrying away reactor heat to warm the air drawn into certain Hanford plant structures now under construction.

The system was designed by engineers of General Electric Company, which operates Hanford for the Atomic Energy Commission and the Charles T. Main firm of Architect-Engineers. Actually, several buildings will be heated by one system, but about half the heat will go into the main structure housing a production reactor now under construction.

Enough heat to take care of the needs of 1,000 average-sized homes will be extracted from the reactor-cooling water and transferred to the air going through plant air conditioners.

As explained by the designing engineers, here is how the system will work:

Water from the Columbia River is pumped through the great Hanford reactors where plutonium is made by the transmission of uranium. The water absorbs immense quantities of heat generated by the process; on its trip through the reactor, dissolved mineral matter in the water becomes slightly radioactive.

Because of this factor, the water from the reactor will be run through a heat exchanger to warm up the water in a secondary piped circuit that will relay the heat to an air-conditioning system in the building, while the radioactive water is carried away. This activity quickly dies away by natural decay, but the concentration of large volumes would create a radioactivity hazard to the plant areas before being harmlessly dissipated in the main stream of the Columbia.

To prevent the movement of contaminated dust particles from the reactor to working areas, a constant flow of air is maintained across the reactors to the outside.

Consequently, no air is reheated and recirculated in the building. Instead, a large volume of air per minute is pumped from the outside, cleaned, heated, and poured into the building.

To pipe the water direct from the reactor through coils in the floor or walls to warm the building by radiant heat would be impractical because of this large volume of fresh air constantly moving in.

The heating system itself is simple in both concept and in execution. It consists of three major elements connected by an appropriate system of piping. First, the primary exchanger, which transfers heat from the effluent stream to an intermediate fluid; second, the secondary exchangers, which transfer heat from this intermediate fluid to

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Leak Detector

Leaks of Freon 12 gas in hermetically sealed air-conditioning systems and dehumidifiers are detected by means of a General Electric Type H leak detector. The leak detector is hooked to an audio system so that the operator will hear a hum when a leak is found She also is able to obtain a visual leak indication on the instrument's dial

the air; and third, a by-pass exchanger, which is arranged to provide adequate heating when the reactor process is shutdown.

The by-pass exchanger is supplied with steam from a central station plant when called on to perform. The primary purpose of the stream plant is to supply emergency electric energy to the plant in the event of a power outage. No extra capacity for heating is considered in installing the steam generators.

A network of piping connects the various process buildings with the primary heat exchanger. This piping is all subsurface and is not insulated, as the primary heat source is both abundant enough and at sufficiently low temperature so that losses to the ground will be considered negligible.

This heat recovery system will answer the question of scores of engineers throughout the nation who have hoped for some economic use of this large energy source. Since September 1944, the huge reactor process plants at Hanford have been pouring vast quantities of waste heat into the Columbia. This heat, a necessary by-product of the nuclear reactions involved in converting uranium to fissionable plutonium, has been of great interest to engineers, who have looked forward to its industrial application.

Atomic By-Product Reduces Test Time in Petroleum Industry

The use of an atomic by-product in a new instrument introduced today by Central Scientific Company will reduce the time cycle required for a basic product control test in the petroleum industry from 4 hours to 5 minutes and, at the same time, increase accuracy more than 100 per cent.

The new instrument, which utilizes an atomic radiation source obtained from the United States Atomic Energy Commission at Oak Ridge, Tenn., measures the percentage hydrogen and hydrocarbon ratio in liquid hydrocarbons by a process that utilizes the absorption of beta rays. The beta rays are high-speed electrons obtained from the radioactive decay of strontium 90.

Known as the Cenco Beta Ray H/C Meter, it was demonstrated for the first time to a group of leading petroleum research and production leaders in attendance at the annual meeting of the American Petroleum Institute.

"Although immediate applications of the beta-ray meter are predominantly in the petroleum and petrochemical industries, we believe it has an excellent potential in other industries where product control is a paramount factor," John T. Gossett, president of Central Scientific Company, said. "It seems likely, for example, that the beta-ray instrument can be used to effect better control in the processing of pharmaceuticals, chemicals, plastics, foods, and in hydrogenation processes."

The determination of the percentage hydrogen in a hydrocarbon is important in the petroleum industry, particularly in the production of jet fuels and aviation gasoline, because it is a measure of power in the fuel. In the past, however, the test in the petroleum industry has been confined mainly to research because of difficulties involved in performing such a test.

Prior to development of the beta-ray meter, standard laboratory procedure for determining the percentage hydrogen in a hydrocarbon or the "H/C ratio" has been through the use of a combustion train, a process which requires approximately 4 hours and the services of a skilled laboratory technician.

Performance of pilot model beta-ray meters indicates that individual determinations can be made with a statistical probable error of 0.02 weight per-cent hydrogen. Corrections, usually of small magnitude, can be made to take into consideration the presence of oxygen, nitrogen, sulphur, lead, and other elements. The combustion technique tests usually resulted in a statistical probable error up to 0.05 weight per-cent hydrogen.

The beta-ray instrument is adapted for control in actual production operations in the petroleum refining industry, according to Mr. Gossett. Preliminary use of the equipment indicates it can be used advantageously at various stages in the production line for gasoline diesel fuel and other petroleum products as a means of obtaining a higher degree of quality control and uniformity in the finished product.

The 10-cubic-centimeter capacity sample cell of the Cenco Beta Ray H/C Meter being filled with a hydrocarbon for the determination of the compound's hydrogen content

Safeguards have been incorporated in the design of the instrument to protect the operator fully from radiation hazards. The radiation source is a sealed capsule contained in a thick copper block that provides shielding, and additional shielding is built into the walls of the ionization chamber. The operator is further protected by the thick walls of the meter housing which acts also as shielding.

The combination of shields is so effective that no stray radiation is measurable on a 0- to 25-milliroentgen-per-hour meter, according to the manufacturer.

The beta-ray source is constructed to radiate equally in two directions. The beam to the left traverses a fixed absorber and proceeds to a beta-ray detector which consists of an ionization chamber designed to collect negative electric charge on the central electrode.

The equal beta ray radiated to the right traverses a sample cell and a wedge-shaped absorber before entering the other beta-ray detector. A galvanometer indicates the difference in magnitude of the electric currents produced in the two ionization chambers. The density of the liquid sample is measured simultaneously by the usual weight displacement method.

To utilize the new instrument, the 10-cubic-centimeter capacity sample cell is filled with the hydrocarbon of unknown hydrogen content. The operator moves the wedge until the galvanometer indicates equal currents are produced in the two ion chambers. At this point, the absorption of the sample in the cell plus that of the wedge equals the absorption of the fixed absorber, and the position of the wedge is recorded and used as a measure of absorption in the wedge.

New Type of Magnet Is Composed of Noncritical Ceramic Material

A completely new type of magnet, composed of ceramic material which is lighter in weight than metal and requires no critical ingredients, was announced recently by The Indiana Steel Products Company.

The new permanent magnet, called Indox, is expected to open new fields for use of magnets in industry and in consumer items, according to Robert F. Smith, president of the company.

Although Indox is composed of materials which are "earthy" in nature and are nonorganic and nonmetallic, Mr. Smith said it is magnetized in the same manner as metals. The magnitude of the magnetizing force required, however, is more than three times that necessary for Alnico, the metallic permanent magnet in common use today.

In addition to being lighter than Alnico, and requiring no critical materials, Indox has twice as much coercive force as Alnico and is a nonconductor, Mr. Smith said. And, he added, it is virtually impossible to demagnetize the Indox material by any ordinary means.

Indox is made from noncritical materials, iron oxide and barium carbonate, and goes through a number of critical cycles in powder preparation, pressing in dies and heat treatment. It was developed in the research laboratories of N. V. Glocilampenfrabrieken at Eindhoven, Holland. It is the first new magnetic substance since the development of Alnico in 1931.

Mr. Smith said that initially Indiana Steel Products would manufacture Indox for use in television focus rings, novelties, toys, and holding devices.

Indox is best suited for uses in which application limits magnetic lengths and in which the magnet may be subjected to high demagnetizing forces, the company president said. In applications involving high frequency, the high resistance minimizes eddy currents, he explained.

Indox has a coercive force of approximately 1,600 oersteds and an intrinsic coercive force of approximately 4,000 oersteds. It can withstand demagnetizing fields above 2,000 oersteds without large loss of magnetic flux.

It is characterized by short magnetic lengths, with an optimum working point of approximately 1,000 gauss at 800 oersteds. For example, Indox loudspeaker magnets have about half the magnetic length of Alnico magnets.

Conveyer belt sorter developed at NBS to sort punched cards. While this model has only ten pockets in which to drop the sorted cards, machines with a much larger number of categories can be built using the same principles of operation

Electromechanical System Developed for Sorting Items

An improved machine for sorting physical objects into a large number of categories has been developed by the National Bureau of Standards (NBS). Designed by J. Rabinow of the NBS electromechanical ordnance laboratory at the request of the Bureau of Census, the device was built to sort punched cards at the rate of 420 cards per minute. The principle, however, is applicable to sorting such other objects as mail, electrical and mechanical components, and even farm produce, as well as checks, invoices, and other papers. Any items that can be separated into a number of subdivisions can be handled by an electromechanical system similar to the NBS sorter.

There are several fundamental approaches to the problem of sorting objects into many classifications. One approach commonly used is to place the objects to be sorted on a conveyer and then to examine them, one by one, as they pass the various sorting stations. Another method, used particularly in sorting punched cards, is to examine all the cards individually at a single reading station and then to direct them immediately into various tracks. A third method, used in the new NBS sorter, is to examine the objects at one station, feed them into a conveyer, and simultaneously put a mechanical address number into each section of the conveyor belt so that the object and its address number travel together. When the object reaches the correct address, or location, a simple recognition device is excited and the object is removed from the conveyer.

The first two methods have the disadvantages of being far too cumbersome and expensive, or of being limited to a relatively small number of sortings. The third method, however, will separate items into a large number of categories with only one examining device and comparatively simple terminal equipment.

MAJOR COMPONENTS

The machine developed at NBS consists of five major components: (1) a sensing unit that reads the data-bearing cards and decides where they should go; (2) an addressing device that loads the conveyer with the cards and their corresponding address numbers; (3) a conveyer belt that carries both the card and its address number; (4) a series of recognition devices, actuated by the information-bearing mechanism of the conveyer belt, which operate trip mechanisms so that the cards are released from the conveyer; and (5) a series of receptacles, or gates to other devices, into which the material borne by the conveyer is sorted.

The NBS machine contains a track on which the cards are pushed by fingers extending down from the conveyer belt directly above. The conveyer belt conveys information in coded form, and the cards are kept in the correct physical location with respect to the address number by the pusher fingers. The conveyer belt is made from two parallel chains whose links are 4 inches on center and are connected by a crossbar at each card position. Each crossbar carries two nylon wheels on which the chains travel and eight nylon cams that act as the mechanical binary address number.

Each of the cams can be set to one of two positions (corresponding to the binary "0" or "1") with the point either down or up. They arrive at the starting end of the conveyer in the clear or "0" position. If it is necessary to tip the cam upward so that it becomes the equivalent of the binary "1," a pawl is moved into its path. Eight cams, each with two possible positions, provide 2^8 or 256 possible binary addresses. Since in general there are 2^n different addresses possible with n cams, it can be seen that the number of categories into which a quantity of items may be sorted is limited only by the number of cams carried by the crossbars connecting the two chains.

SORTING OPERATION

In the sorting operation, the cards first are dealt from the bottom of the stack and pass under a conventional 80-column card reader. When the information on the card is decoded, an electric device decides into which pocket the card is to go, and the cams are set up with the correct address number. The card then is pushed onto the track. As the cams move down the conveyer with their associated cards, they pass under a series of switches, one set at each pocket. A cam in the upward position will actuate a switch; one in the downward position will not. By properly wiring a set of eight switches, any particular 8-digit binary address number can be recognized, exciting a mechanism that will deflect the card from the track into one of the pockets.

While conveyer belt sorters of this general type are not new, the NBS machine has several definite advantages. It is not a synchronous machine; that is, the card spacing in the conveyer does not have any relation to the spacing of the pockets. This leads to a saving in the power supply inasmuch as the cards cannot all be dropped simultaneously. However, if the pockets were to have the same spacing as the cards on the conveyer belt, then the cards could be dropped simultaneously although this would not normally occur. Large sections of the belt may be added, as well as groups of pockets in any desired spacing, but the recognizing element in all cases must be spaced a constant distance from its associated pocket. It is also a simple matter to provide more than one pocket for one category; when one pocket fills, subsequent cards can be deposited in a second pocket. Moreover, it is relatively easy to provide a counter which can be associated with each pocket.

If a machine similar to the NBS model were to be designed for sorting mail, it is expected that for some time to come human operators would have to read the addresses on the letters. By means of suitable keyboards, the operators would set up the conveyer belt as the mail is fed into the conveyer. As the speed of the conveyer normally would be much higher than possibly could be matched by one operator, several people would be placed along the belt to feed it. Each operator would set up a series of pawls corresponding to the address on his letter and then would press a transfer key. The conveyer belt cams would be set up, and the letter (or package) would be inserted into the conveyer at the same time. It would be quite simple to provide an additional cam in each set to indicate that a particular space is filled; this would prevent a letter from being transferred until an empty section had arrived at the feeding station.

NEW BOOKS • • • • •

The following new books are among those recently received at the Engineering Societies Library. Unless otherwise specified, books listed have been presented by the publishers. The Institute assumes no responsibility for statements made in the following summaries, information for which is taken from the prefaces of the books in question.

CONTRIBUTION A L'ETUDE EXPERIMENTALE DES ECOULEMENTS GAZEUX RAPIDES PAR LES METHODES DE PERTURBATION UTILISATION DES ULTRASONS. By Genevieve Dubois. France, Ministere de l'Air, Publications Scientifiques et Techniques, Number 269, Paris, France, 1952. 55 pages, $10^3/_4$ by 7 inches, paper. Ffrs. 250. An experimental study by the use of ultrasonic perturbations of rapid gaseous discharges. The method and equipment are described and the results are evaluated.

DISLOCATIONS AND PLASTIC FLOW IN CRYSTALS. By A. H. Cottrell. Oxford University Press, London, England (distributed in United States by Oxford University Press, 114 Fifth Avenue, New York 11, N. Y.), 1953. 223 pages, $9^3/_4$ by $6^1/_4$ inches, bound. $5. This study covers the interpretation of slip in crystals; elastic properties of dislocations; dislocations due to crystal structure; theories of the yield strength; and working hardening, annealing, and creep. Writing for metallurgists and engineers as well as for theoretical and experimental physicists, the author has emphasized the qualitative physical ideas rather than their formal mathematical developments, and has kept the mathematics to a minimum. Numerous references to the literature of the subject appear throughout.

DRUCKWELLEN-SPULUNG BEI ZWEITAKT-MOTOREN. (Mitteilungen aus dem Institut für Thermodynamik und Verbrennungsmotorenbau an der E.T.H., Number 12.) By Yian-Nian Chen. Verlag Leeman, Zürich, Switzerland, 1953. 93 pages, $9^1/_2$ by $6^3/_4$ inches, paper. Sw. Frs. 10.40. A dissertation on pressure-wave scavenging in 2-stroke engines, which provides both a theoretical discussion and a report on an experimental investigation of a diesel engine, fully detailed with graphs and calculations throughout.

ELECTRONIQUE GENERALE. By A. Blanc-Lapierre, G. Goudet, and P. Lapostolle. Editions Eyrolles, Paris, France, 1953. 394 pages, $9^3/_4$ by $6^1/_2$ inches, bound. Ffrs. 3208. Part I discusses the electron and its electromagnetic properties. Part II deals briefly with vacuum technique and with the electron theory of metals, and at considerable length with electronic emissions: thermoelectric, photoelectric, secondary electronic emissions, and so forth. Part III takes up electron optics and its applications.

ELECTROSTATIQUE ET MAGNETOSTATIQUE. By E. Durand. Masson et Cie, Paris, France, 1953. 774 pages, $9^1/_2$ by 7 inches, bound. Ffrs. 6335. The opening chapters of this comprehensive treatise are devoted to electrostatics: fundamental equations of distribution of charges, conductors, dielectrics, forces within the electrostatic field, and various special topics such as electrostriction, piezoelectricity, and so forth. Succeeding chapters deal similarly with magnetostatics, and include discussions of diamagnetism, paramagnetism, and ferromagnetism. The extensive mathematical treatment covers analytical solutions for two and three variables, with a large number of numerical solutions.

ENGINEERING STATISTICS AND QUALITY CONTROL. By Irving W. Burr. McGraw-Hill Book Company, Inc., 330 West 42d Street, New York 36, N. Y., 1953. 442 pages, $9^1/_4$ by $6^1/_4$ inches, bound. $7. A textbook designed primarily for undergraduate and graduate students, but of interest also to engineers and executives in industry who are concerned with statistical quality control. Subjects covered include frequency distribution, the normal curve, control charts, probability, sampling, and the place of statistics in an industrial organization. A glossary of standard symbols is included.

FATIGUE OF METALS. By R. Cazaud. Translated by A. J. Fenner. Philosophical Library, 15 East 40th Street, New York 16, N. Y., 1953. 334 pages, 10 by $6^1/_2$ inches, bound. $12.50. This volume is essentially a survey of the characteristics and behavior of metals under cyclic stress, the practical side of which is emphasized by taking into account the effect of contributing factors such as size and shape of parts, surface conditions, temperature, and corrosion. Test methods and testing machines are explained and described. The final chapter on "improving the fatigue strength of machine components" represents an important part of the author's aim in writing the book.

HEAT TRANSFER. Engineering Research Institute, University of Michigan, Ann Arbor, Mich., 1953. 286 pages, $9^1/_4$ by $6^1/_4$ inches, bound. $5. A group of 11 lectures by authorities in the field opening with a discussion of heat transfer problems in general and, in particular, the effect on materials of high thermal gradients. Succeeding lectures discuss specific problems that arise when thermal gradients are present in materials ranging from solids through liquid metals, liquids, and gases, including rarefied-gas dynamics. Each of the papers includes a list of references.

AN INTRODUCTION TO AERONAUTICAL ENGINEERING. Volume 1: Mechanics of Flight. By A. C. Kermode. Sir Isaac Pitman and Sons, Ltd., London, England (distributed in United States by British Book Centre, Inc., 122 East 55th Street, New York 22, N. Y.), sixth edition, 1952. 372 pages, $9^3/_4$ by $5^3/_4$ inches, bound. $4.50. One of a series of three volumes dealing with the elements of aeronautical engineering. It covers airflow, airfoils, propulsion methods, level flight conditions, gliding and landing, performance characteristics, stability and control, and high-speed flight considerations. The volume has been thoroughly revised including the addition of jet and rocket propulsion principles and the entire chapter on high-speed flight. Additional practical data are appended.

AN INTRODUCTION TO RELAXATION METHODS. By F. S. Shaw. Dover Publications, Inc., 1780 Broadway, New York 19, N. Y., 1953. 396 pages, $8^1/_4$ by $5^1/_2$ inches, bound. $5.50. A detailed guide for solving problems arising in fluid mechanics, the design of electric networks and machinery, forces in structural frameworks, stress distribution, electron-optics, and many other fields. The broad application of the book has been made possible by emphasis on the different types of equations solvable by these methods rather than on specific subject problems. The treatment is logical and fully detailed.

KREISELGEBLASE UND KREISELVERDICHTER. By Friedrich Kluge. Springer-Verlag, Berlin, Germany, 1953. 301 pages, 11 by 8 inches, bound. DM 58.50. Intended for students as well as design engineers, this text on turboblowers and turbocompressors of radial design covers both theory and practice. Topics covered include physical principles, single- and multiple-stage machines, control principles and devices, machine elements, assembly, and operation.

MACHINES THAT BUILD AMERICA. By Roger Burlingame. Harcourt, Brace and Company, 383 Madison Avenue, New York 17, N. Y., 1953. 214 pages, $8^1/_4$ by $5^1/_2$ inches, bound. $3.50. A history of the development of American mass production seen as the result of the demands of economic necessity and as a factor in the westward settlement and unification of the United States. The historical background and influence of many inventions are discussed, and the contributions of numerous inventors—Oliver Evans, Hargreaves, Howe, Eastman, and Ford, among others—are described.

DISLOCATIONS IN CRYSTALS. By W. T. Read, Jr. McGraw-Hill Book Company, 330 West 42d Street, New York 36, N. Y., 1953. 228 pages, $9^1/_4$ by $6^1/_4$ inches, bound. $5. An introductory and systematic account of currently well-established principles, intended as a forerunner in the development of a branch of solid-state physics—useful in practical metallurgy. Part I deals with fundamental ideas of dislocation theory, basic geometrical and analytical properties of dislocations, and the role of dislocations in the plastic deformation of metals and other crystalline solids. Part II applies dislocation theory to the study of crystal growth and grain boundaries.

DER ELEKTRISCHE DURCHSCHLAG VON GASEN. By Berthold Gänger. Springer-Verlag, Berlin, Germany, 1953. 581 pages, $9^1/_4$ by $6^1/_2$ inches, bound. DM 58.50. A comprehensive survey and evaluation of the published literature on electrical discharge in gases. In addition to the extensive treatment of conditions in electric equipment, there is a brief discussion of lightning effects. The book is designed to help the specialist on individual problems as well as provide the student with a thorough understanding.

YEAR BOOK OF THE HEATING AND VENTILATING INDUSTRY 1953. Issued in collaboration with the Association of Heating, Ventilating and Domestic Engineering Employers. Technitrade Journals, Ltd., London, W. C. 1, England, 1953. 298 pages, $8^1/_2$ by $5^1/_2$ inches, bound. 7s. 6d. An annual compilation of reference data, containing a bibliography of heating and ventilating literature for the preceding year, a list of pertinent British standards and codes, a list of British heating and ventilating engineering firms, trade names, and a buyers' guide. A few articles on technical or trade topics appear in each volume.

PAMPHLETS • • • • •

The following recently issued pamphlets may be of interest to readers of "Electrical Engineering." All inquiries should be addressed to the issuers.

Air-Conditioning Conference Proceedings. Proceedings of the technical conference on Year-Round Residential Air Conditioning held in April 1953 have been published. The published volume includes the technical papers presented during the 2-day conference. Among the topics covered are technical aspects of modern residential construction, a review of the American Society of Heating and Ventilating Engineers' research program, load calculations for residences, problems of control and operation of air-conditioning systems, and a review of the research work done at the University of Illinois. Copies of the volume may be secured from the Department of Mechanical Engineering, Lehigh University, Bethlehem, Pa.

National Electrical Code. The 1953 revision of the National Electrical Code has been published by the National Fire Protection Association. This edition has been adopted as an American Standard by the American Standards Association. Some significant changes and additions affect electrical receptacles, portable electric equipment, armored cable, uses for nonmetallic sheathed cable, markings on flexible cords, and many others. 616 pages, cloth bound; 488 pages, paper bound. $3.00, cloth bound; $1.00, paper bound. The cloth-bound edition contains 128 pages of excerpts from the significant electrical provisions of 62 other National Fire Protection Association standards. Copies are available from National Fire Protection Association Publications Services, 60 Batterymarch Street, Boston 10, Mass.

Quartz Crystal Units and Circuitry. "Current Status of Quartz Crystal Units and Circuitry for Frequency Control" is a guide for electrical technicians seeking crystal units of the degree of stability required by rigid specifications in some of their circuits. The volume shows how this may be achieved successfully with the application of the series-resonant types of crystal units and associated circuitry. To increase simplicity of operations, the use of parallel-resonant-type crystal units and associated circuitry is recommended. The hope is expressed that with increased knowledge of the proper characteristics of certain crystal units, operations below series resonance will be made possible. 34 pages, with diagrams, photographs, and charts. $1.00. Available from the Office of Technical Services, United States Department of Commerce, Washington 25, D. C.